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ABSTRACT

Incorporated are abstracts of papers presented at the annual conference of the National Association for Research in Science Teaching held in Detroit, Michigan, March 27-29, 1973. The papers were presented during a three-day period. The first day's presentations related to the topics of simulation techniques, pictorial communication research, concept learning, test construction, teacher education, instructional procedures, learning theory, educational research in foreign countries, visually perceived nonverbal behaviors, and student achievement. Presented on the second day were the president's address and topics dealing with the global view of science education research, student characteristics, curriculum development, facility design, teaching strategies, and classroom vignettes workshop. For the third day, topics were related to science teaching research in a larger context, information theory, and the future direction in secondary science teacher education. (Use of RESEARCH IN EDUCATION and other ERIC publications to retrieve the original papers or symposia is recommended.) (CC)

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NATIONAL ASSOCIATION
FOR RESEARCH IN SCIENCE TEACHING
46TH ANNUAL MEETING
ABSTRACTS OF PRESENTED PAPERS

Detroit Hilton Hotel
Detroit, Michigan
March 27-29, 1973

ERIC Information Analysis Center for
Science, Mathematics, and Environmental Education
400 Lincoln Tower
The Ohio State University
Columbus, Ohio 43210

PREFACE

The ERIC Information Analysis Center for Science, Mathematics, and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Detroit, Michigan, March 27-29, 1973.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC Staff to provide a general format for the abstracts. Special recognition should be given to Dr. Wayne W. Welch who organized the program and obtained most of the abstracts, to Dr. Patricia Blosser for extensive assistance in preparing the abstracts, and to Mrs. Maxine Weingarth, Miss Linda Hemmler, and Mrs. Charlotte Helgeson for typing and compiling.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Research in Education and other publications of the ERIC system.

February, 1973

Stanley L. Helgeson
Associate Director
Science Education

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GENERAL SESSION I

Chairman: J. David Lockard, University of Maryland, College Park, Maryland

Speaker: Christine McGuire, University of Illinois Medical Center
Chicago, Illinois

"Simulation Technique in the Teaching and Testing of Problem-Solving Skills"

CONCURRENT SESSIONS I

Session Ia - Symposium, Statler 1

"Pictorial Communication Research in Science Education"

Chairman: David P. Butts, University of Texas, Austin, Texas

Participants: William G. Holliday, The University of Calgary, Calgary, Alberta, Canada

Mary Lou Koran, The University of Florida, Gainesville, Florida

John J. Koran, Jr., The University of Florida, Gainesville, Florida

Alan M. Voelker, The University of Wisconsin, Madison, Wisconsin

K. Michael Hibbard, Greenwich Public Schools, Greenwich, Connecticut

Discussants: Joseph Novak, Cornell University, Ithaca, New York

Mary Budd Rowe, The University of Florida, Gainesville, Florida

PICTORIAL COMMUNICATION RESEARCH IN SCIENCE EDUCATION

William G. Holliday
The University of Calgary
Calgary, Alberta, Canada

John J. Koran Jr. and Mary Lou Koran
The University of Florida
Gainesville, Florida

Alan M. Voelker
The University of Wisconsin
Madison, Wisconsin

K. Michael Hibbard
Greenwich Public Schools
Greenwich, Connecticut

How can pictures help people to learn science? What type of pictures are most appropriate for various kinds of learners? What are the theoretical information processing mechanisms that account for the effects of pictures in science instruction? How should the verbal and pictorial instructional material be arranged to complement each other? Participants in the symposium will discuss these questions as well as results from some of their own experiments, and will pose research questions that need empirical investigation. Specific direction will be offered to researchers interested in pursuing this area. The instructional research literature indicates that questions are usually directed toward the verbal medium, with little or no concern for the potential role of the pictorial medium. However, examination of science textbooks reveals a heavy reliance upon the picture to help communicate information to the learner. Instructional developers usually rely upon their intuition when making decisions about the inclusion and placement of pictures into science textbooks. We need to differentiate between those pictures that are facilitating learning (i.e., functioning as cues, reinforcers, or effective examples) and visuals that are merely serving as pictorial embellishments. Participants will discuss the following topics and research questions:

I. Aptitude X treatment interaction research and theory provide ample indication that the effects of visual communications are different depending on the characteristics of the Ss. This paper will discuss the aptitude X treatment hypothesis and some research bearing upon the differential effects of visual stimuli during instruction. It will propose a process model for the analysis of tasks and treatments to determine what aptitudes are likely to be related to them.

II. What are elementary school children's perception of the usefulness of different instructional pictures as related to their individual attainment of the science concepts presented? Analysis of the data, using multivariate and analysis of covariance techniques, indicates that the subject's perception of the professionally-drawn, detailed-pictures was dependent upon the specific verbal concept-picture relationships investigated.

III. The research literature suggests that pictures may have the following advantages:

(1) The information in a picture is available for much longer than similar information in a verbal statement;

(2) Graphic techniques allow characteristics of an object or an interaction to be emphasized and thus a picture may have a lower noise/signal ratio than either a verbal statement or the actual object.

These hypotheses and data pertaining to the recall of prior concrete experiences required by certain children to correlate concepts such as kinetic and electrical energy will be discussed.

IV. The research literature suggests that those instructional pictures investigated do not significantly facilitate comprehension. Eighty high school subjects were randomly assigned to verbal and verbal-picture biology instructional treatment groups. A twenty-three page verbal description of the experimental effects of auxin were presented. In addition, the verbal-picture group was given "text-book-like" simplified line diagrams illustrating the verbal descriptions for each page. Contrary to previous studies, analysis of variance indicated that the verbal-picture group scores in this experiment were significantly higher ($p = .01$) based upon a thirty item verbal comprehension post test ($\alpha = .86$).

The quality of the symposium and the individual contributions will be evaluated by two discussants.

Session Ib - Discussion Paper, Statler 2

Chairman: Glenn D. Berkheimer, Michigan State University, East Lansing, Michigan

1. "An Investigation of the Effectiveness of Formative Evaluation and Remediation in Achieving Mastery of Intellectual Skills." Ronald L. Fiel, Morehead State University, Morehead, Kentucky.

AN INVESTIGATION OF THE EFFECTIVENESS OF FORMATIVE EVALUATION AND REMEDIATION IN ACHIEVING MASTERY OF INTELLECTUAL SKILLS

Ronald L. Fiel
Morehead State University
Morehead, Kentucky

The purpose of this investigation was to determine if Gagné's hypothesis concerning the learning of intellectual skills, one of five domains or types of learning, was valid. Gagné has proposed that the learning of intellectual skills requires prior learning of prerequisite tasks and that attention to prerequisites should be more effective than repeated practice of the skill. To test this hypothesis, two forms of instruction were compared for effectiveness in remediating errors made in learning intellectual skills: providing an alternative form of instruction by attending to prerequisite tasks not covered by main-line instruction, or providing additional practice items.

The subjects of the experiment, 90 eighth-grade general science students, were ranked on their Total Arithmetic Skills score of the Iowa Tests of Basic Skills and within triads, randomly assigned to one of three treatment groups. Each treatment group was subdivided into seven levels of the classification variable (Total Arithmetic Skills score). The classification variable was used to increase the precision of the investigation relative to the treatment variable rather than to examine interaction effects between the treatment and classification variables.

All subjects studied main-line programed instruction on the construction and interpretation of graphs. After each of three lessons, each subject took a diagnostic test covering the objectives of the instruction. The results of the diagnostic test were used to determine which students needed addition instruction. Subjects in Group 1 received an alternative form of instruction as remediation. Subjects in Group 2 received additional practice items as remediation, and subjects in Group 3 received no remedial activities. All remedial materials were paper and pencil programs.

A criterion measure was developed to cover a learning hierarchy consisting of a terminal task and 12 subordinate skills which had been the objectives of the instruction. This criterion measure, administered to all subjects following the third day of remedial activity, served as the dependent variable for a factorial analysis of variance with three levels of the treatment variable and seven levels of the classification variable.

Students receiving both kinds of remedial instruction did significantly better ($p < 0.05$) on the criterion measure than those receiving only main-line instruction. Students receiving an alternative form of instruction did significantly better ($p < 0.05$) than those receiving additional practice items as remediation. The results support Gagné's hypothesis that learning intellectual skills requires the mastery of prerequisite tasks and that study on the prerequisites to unlearned intellectual skills will be more effective in remediating errors than additional practice on unlearned intellectual skills.

Two groups of educational practitioners can be affected by the findings in this study. Teachers attempting to individualize instruction in their classroom may produce higher student performance in learning intellectual skills if they diagnostically test students and select alternative instruction to remediate detected errors in learning. Curriculum developers may produce more effective instructional materials if they build in for students, remedial branches which attend to prerequisite skills and not just provide "more of the same" instruction on unlearned tasks.

Session Ic - Concept Learning, Hilton 1

Chairman: Richard L. Sagness, University of South Dakota, Vermillion, South Dakota

1. "The Ability of Teacher Identified Non-College Bound High School Biology Students to Identify and Apply Selected Princepts of Biology." Richard A. Shipe, Trinity College, Hartford, Connecticut and H. Seymour Fowler, Pennsylvania State University, University Park, Pennsylvania.
2. "Science Misconceptions Among Certain Groups of Students in Lebanon." George I. Za'Rour, American University of Beirut, Beirut, Lebanon.
3. "A Study of the Effectiveness of Three Types of Visual Devices on the Achievement of Selected Theoretical Concepts by Elementary Children." Patrick J. Mc Intyre, Western Washington State College, Bellingham, Washington.

THE ABILITY OF TEACHER IDENTIFIED NONCOLLEGE-BOUND HIGH SCHOOL BIOLOGY STUDENTS TO IDENTIFY AND APPLY SELECTED PRINCEPTS OF BIOLOGY

Richard A. Shipe
Trinity College
Hartford, Connecticut

and

H. Seymour Fowler
Pennsylvania State University
University Park, Pennsylvania

Objectives of the Inquiry: The purpose of this study was to investigate the degree to which teacher-identified noncollege-bound high school biology students have developed the ability to identify and apply selected princepts of biology. Subproblems were concerned with determining if: (1) there is a significant relationship between the ability to identify and apply selected princepts of biology, (2) there is a significiant correlation between the student's ability to identify and apply selected princepts of biology and the reported I.Q. score, and (3) there is a significant difference in the ability of noncollege-bound high school students to identify and to apply selected princepts of biology between: (a) students completing traditionally organized and BSCS-organized biology courses, and (b) males and females.

Methods and/or Techniques: To investigate these problems a comprehensive listing of biological princepts was compiled and was submitted to a panel of high school biology teachers of noncollege-bound pupils to judge those princepts deemed essential to noncollege-bound biology students. A two part, multiple-choice test was developed from the judges' listing of 73 essential princepts of biology. Item analysis was conducted on two pilot administrations of the test and measures of reliability were obtained on each administration. Validity was established by the test items and the princepts. Subject matter experts judged the accuracy of the content of the test. A reading specialist assessed the readability of the instrument.

The test was administered to noncollege-bound students in biology classes in nineteen randomly-selected high schools in Connecticut. The data were analyzed to determine means, grand means, product moment correlations, and analysis of covariance.

Data Sources: Ratings of essential biological princepts were compiled from a selected panel of 18 teachers of noncollege-bound biology students. Test data were provided by 19 cooperating school districts and comprised a sample of 1073 students representing five percent of the noncollege-bound biology student population in Connecticut.

Results and/or Conclusions: Noncollege-bound high school biology students in Connecticut did not develop adequately the ability to identify and apply selected princepts of biology. The noncollege-bound biology student's ability to identify princepts is different from, though related to, ability to apply selected princepts of biology. When I.Q. is controlled, noncollege-bound students in traditionally organized biology courses scored significantly higher on the test of ability to apply selected princepts of biology than students completing BSCS organized biology courses. Males have developed a significantly higher ability to identify selected princepts of biology than females.

Significance: This investigation has identified listings of biological princepts deemed essential for inclusion in high school courses for noncollege-bound students. An evaluative instrument to establish norms for judging the noncollege-bound high school students' ability to identify and apply selected princepts of biology. Unlike other comparisons of BSCS and traditionally organized biology programs, differences were obtained favoring noncollege-bound students in traditional courses.

SCIENCE MISCONCEPTIONS AMONG CERTAIN GROUPS OF STUDENTS IN LEBANON

George I. Za'rour
American University of Beirut
Beirut, Lebanon

Objectives: The major purpose of the study was to identify erroneous notions about some scientific facts and concepts and to determine the extent to which they are prevalent among certain groups of students in the Beirut, Lebanon, area. The erroneous notions which occur with relatively high frequency are referred to as misconceptions. Using this definition, the study also aimed at testing the following hypotheses:

1. Science misconceptions decrease with increasing years of education.

2. Male students are just as prone to science misconceptions as female students.

Some other minor hypotheses were also tested.

Methods and Data Sources: 1. Subjects - The Ss were 1444 high school (freshman and junior) and university (mostly sophomore) students from 11 high schools in Beirut and its neighborhood and from the American University of Beirut. Except for 130 students from the American Community School, all the Ss were, or had been, part of the Lebanese system of education at the pre-university level. 2. The Instrument - A 40-item multiple choice test with four alternatives per item was developed after analyzing the results of a pilot study. About 20 items belong to physics while the others are distributed among earth and space science, chemistry and biology. Eight items have been judged to involve specific information. 3. Procedure - The test was administered to whole classes in the selected schools and to students enrolled in representative university sophomore courses. Item analysis was carried out, yielding, among other data, the percentage popularity of each alternative for the total sample and for each of the relevant subgroups. The responses of the 130 students from the American school were analyzed separately throughout the study. A distracter which was selected by 25 percent or more of the respondents in each class level was labelled as a misconception.

Results: The results indicate that 17 distracters were selected by 25 percent or more of the respondents at each of the three levels. The total group selected six distracters with a percentage of 50 or more. The top three of these are: (a) When compared to moist air, the density of dry air is smaller. (b) It is impossible to change an element such as nitrogen into another such as oxygen. (c) As you are listening to a radio using electricity at home, the electrons that flow into the radio all change into energy (light, sound or heat).

Considering the total responses, there is enough evidence supporting the hypothesis that misconceptions tend to decrease with years of education. However; a closer study revealed that the opposite holds for some of the misconceptions. There was a significant sex difference with male students subscribing to fewer misconceptions. This was more pronounced at the high school level.

Significance: Effective teaching is supposed to start with student background and previous experiences. One of the considerations in effective science teaching is the identification of common errors in the popular notions of scientific facts and concepts. The study revealed the extent to which some concepts are understood. It showed that some of the notions are either not taught at all or are not taught properly. The results should be fruitful to science teachers, textbook writers, and to those interested in adult education and popularized science.

A STUDY OF THE EFFECTIVENESS OF THREE TYPES OF VISUAL DEVICES ON THE ACHIEVEMENT OF SELECTED THEORETICAL CONCEPTS BY ELEMENTARY CHILDREN

Patrick J. Mc Intyre
Western Washington State College
Bellingham, Washington

Objective: The purpose of the study was to determine the relative effectiveness of three different types of visual devices in an instructional program designed to teach an understanding of selected theoretical science concepts to elementary school children. The visual devices were prepared using Bruner's three modes of representation (enactive, iconic, and symbolic) as guides; the visual devices differed in levels of abstraction.

Method and Data Source: The enactive visual devices were felt models which the students could perceive being transformed without recourse to imagery or language. The iconic visual devices were pictures of the enactive devices which required the use of imagery for their transformation. The symbolic visual devices were pictures in which the enactive figures were replaced by alphabetic characters which required interpretation as well as imagery for their use.

Six classes, selected from an available population of nineteen classes, were randomly assigned two to each treatment. Seven 25 minute lessons were given by the principal investigator to each class. A paper and pencil test (Test of Introductory Electrostatics) and a competency test (individual interview with demonstrations) were used as pre- and post-tests. The preparation and validation of the tests were major aspects of the study. The validation of the tests included considerations of content validity, construct validity, internal consistency and test-retest reliability. Class scores were used as the statistical unit for analysis.

A separate sample pre-test-post-test design was used in the study. The null hypothesis of no effect due to the type of visual device used in instruction was tested utilizing four subtest scores and the competency test. A two-way analysis of variance where the level (pre- and post-test scores) were nested within the treatments (enactive, iconic, and symbolic) was used. Distribution of scores on the pre-test and the post-test were analyzed for trends.

Results: The null hypothesis was not rejected. The type of visual device used in instruction did not have a significant effect on achievement as measured by the Test of Introductory Electrostatics and the competency test. Students in all classes did equally well.

Significance: It was concluded that it is reasonable to teach the basic concepts of electrostatics to fourth grade students. Students at this grade level are capable of working with theoretical concepts at the comprehension and application levels. Students do find models useful in explaining phenomena, and model building could be a skill to be developed in an elementary school science curriculum.

Session Id - Test Construction, Hilton 3

Chairman: Rita Peterson, University of California, Berkeley, California.

1. "Development of Views and Preferences - C." Lowell A. Seymour, Mid-Continent Regional Education Laboratory, Kansas City, Missouri.
2. "Correlational and Factor Analysis of Certain Tests Commonly Used to Measure Science Inquiry Goals." Frank D. Breit, University of South Florida, Tampa, Florida.
3. "Development and Use of an Instrument to Measure Elementary School Children's Scientific Curiosity and Interests." Rayman P. Richardson, Fairmont State College, Fairmont, West Virginia.

DEVELOPMENT OF VIEWS AND PREFERENCES - C

Lowell A. Seymour
Mid-Continent Regional Education Laboratory
Kansas City, Missouri

Objectives: 1. To write an instrument to distinguish Inquiry Role Approach students from non-Inquiry Role Approach students. 2. To establish criterion levels for the items.

Methods: One hundred and forty items were written to measure student attitude toward social interactions, cognitive interactions, and teacher or class procedures. Student attitude was divided into two parts: views and preferences. A view and a respective preference item was written. Views items were descriptive - students indicated whether or not a practice existed or a behavior occurred. Preference items measured whether students indicated a like or preference for the practice or behavior.

These items and their categorizations were judged by five judges.

Data Sources: The items were administered to Inquiry and non-Inquiry Role Approach classes after one year of instruction.

Results and/or Conclusions: Fifty items were found to discriminate Inquiry from non-Inquiry Role Approach teachers and (tenth grade biology) students. A chi-square was calculated for each of the original 140 items.

Criteria levels were established for the items based on the responses of students.

Significance: An instrument is now available that is sensitive to an inquiry program and that is useful for tenth grade biology teachers who are interested in determining the views and preferences of their students regarding certain aspects of inquiry.

CORRELATIONAL AND FACTOR ANALYSIS OF CERTAIN TESTS COMMONLY USED TO MEASURE SCIENCE INQUIRY GOALS

Frank D. Breit
University of South Florida
Tampa, Florida

Objectives: Attempts to evaluate the effectiveness of the new science curricula have led to a search for instruments which could objectively measure the new inquiry related goals. At the present time two of the instruments most commonly used for this purpose are the Test on Understanding Science (TOUS) and the Watson-Glaser Critical Thinking Appraisal (WG). The objective of this study is to determine empirically the interrelationships and the factor structure of the TOUS and the WG from which inferences may be drawn about the structure of these instruments.

Methods: Scores on the following tests were obtained from a sample of tenth grade students:

(1) Test on Understanding Science - Form W (TOUS),
(2) Watson-Glaser Critical Thinking Appraisal - Form YM
(3) Stanford Achievement Test - High School Science - Form Y
(4) Syllogistic Reasoning - Nonsense Syllogisms Test
(5) Induction - Letter Sets Test

The latter two tests were viewed as marker tests of induction, and deduction, respectively.

Data from the Florida Statewide Ninth Grade Tests were also used in the analysis. These tests include measures of scholastic aptitude as well as measures of academic achievement in English, social studies, math, and science. Scores from a total of twenty subtests were available for the analysis.

Pearson product moment correlations were calculated to determine a subtest correlation matrix as well as a total test correlation matrix. Principal components factor analysis and Kaiser Varimax rotation of all factors with Eigen values in excess of one were conducted for the subject score matrix, and the total test score matrix, independently.

Data Sources: The subjects were 149 tenth grade students at Robinson High School, Hillsborough County Public Schools, Tampa, Florida, who were selected to represent the range of ability characteristic of the tenth grade population. The series of five tests were administered during February, 1972.

Results: In the rotated factor analysis four factors were identified. Factor I, accounting for 51% of the variance, had factor loadings above .75 from all nine Florida Ninth Grade Tests. No other subtest loaded above .41. Factor II, accounting for 28% of the variance, had loadings of .68, .69 and .76 from the three TOUS subtests. Other high loadings were .69 on SAT Science, and .56 and .63 on WG Deduction and WG Inference, respectively. Factor III, accounting for 12% of the variance, had a high loading, .76 on WG Assumptions and a moderate loading, .56 on WG Evaluation. Factor IV, accounting for 9% of the variance, had a high loading, .89 on Nonsense Syllogisms. No other subtest loaded above .39.

Significance: In the rotated analysis, Factor I appears to be a general achievement factor. The low loadings of the TOUS subtests on this factor indicate that the TOUS is measuring something different from general achievement. The high loadings of the TOUS subtests and the SAT Science on Factor II appear to indicate considerable overlap in what these two instruments measure. This could be interpreted to mean that the TOUS measures nothing more than general science achievement. Additional studies utilizing different measures of science achievement, are needed to either add support to or alter the above interpretation.

The WG subtests did not load solely on any one factor. Instead, two subtests loaded moderately high with the TOUS and SAT Science, and two loaded on another factor. The fifth subtest loaded on three factors. The loadings of WG Deduction and WG Inference with the TOUS and SAT Science suggests that certain activities within these subtests are similar to activities in TOUS and SAT Science. The nature of these commonalities requires further analysis. The loading of WG Assumptions and WG Evaluation on a separate factor indicates that at least these two subtests measure something different from general achievement and science achievement, perhaps a critical thinking ability. The failture of any of the WG subtests to load highly with either of the marker tests adds to the difficulty in developing a clear interpretation of the test structure. Before such an interpretation is possible further studies are needed including other marker tests, such as problem solving, reasoning, judgement and evaluation.

DEVELOPMENT AND USE OF AN INSTRUMENT TO MEASURE ELEMENTARY SCHOOL CHILDREN'S SCIENTIFIC CURIOSITY AND INTERESTS

Rayman P. Richardson
Fairmont State College
Fairmont, West Virginia

Objectives: The purpose of this study was two-fold. First, an instrument was developed to measure elementary school children's scientific curiosity and interests in science. Second, the instrument was used to study the scientific curiosity and interests of children in grades six through nine.

Methods: The 110-item inventory was divided into four sections: (1) 20 scientific curiosity items, (2) 48 scientific interest items based upon expressed preferences for certain activities, referred to as the "like" scale, (3) 32 scientific interest items based upon expressed past experiences with various activities, referred to as the "have" scale, and (4) 10 items designed to assess the student's self-perception of his own curiosity.

The test-retest of 178 students revealed reliabilities of 0.44 for the curiosity scale, 0.69 for the "like" scale, 0.73 for the "have" scale, and 0.68 for the self-perception of curiosity scale. The total test-retest reliability was 0.72. Using the entire sample of 1595, the Kuder-Richardson #21 reliability was 0.93.

Data Sources: Factor analysis of the 1595.students' responses revealed nine factors: (1) general interest in science, (2) general curiosity about surroundings, (3) plants and rocks, (4) curiosity I, (5) curiosity II, (6) mechanical synthesis and analysis, (7) observational processes, (8) animals, and (9) read. Despite the wide geographical separation of the two sub-samples, 1054 students from the Portland (Oregon) Public Schools and 545 students from the Columbus (Ohio) Public Schools, these nine dimensions remained fairly stable.

Results: An investigation was made of the student variables that would predict the student's scores on the nine factors. Selected were age, sex, grade level, intelligence, science grades, scientific curiosity rating by the teacher, and ADC level of the school. Multiple regression analysis revealed that none of the selected variables accounted for more than 18 per cent of the variance in the factor scores, with one exception. Sex was able to account for 44 per cent of the variance in the factor scale score pertaining to mechanical synthesis and analysis.

Using one-way analysis of variance among the student's means on the "like" scale in 24 classes, significant differences at the one per cent level in all of the twelve science content areas were found. A one-way analysis of variance using the "have" scale revealed significant differences at the one per cent level in ten of the twelve science content areas. No significant differences were found among the student means on either of the curiosity scales.

The relationship between the teacher's and the class' mean scores on the "like" scale revealed that only 14 teacher-class pairs of the 43 investigated showed positive correlations significant at the .05 level. There were five teacher-class pairs exhibiting negative correlations that were significant at the .05 level.

Significance: This study has shown that the science interests, and to a lesser extent the scientific curiosity, of upper elementary school children can be measured using a short paper-and-pencil type test. Measurements from this inventory may be used in curriculum planning and assessment at any level from an individual student to a class and, possibly, to the national level.

With the improvement of inventories such as the one used in this study, the identification of the factors affecting the development of a student's interest in and curiosity about science could be made. Thus, optimizing these factors would permit further strengthening of science education in our schools and society at large.

CONCURRENT SESSION II

Session IIa: - "An Hour With" Session, Statler 1

Chairman: Kenneth D. George, University of Pennsylvania, Philadelphia, Penn.

"An Hour With David P. Butts About Performance Based Science Teacher Education"

David P. Butts
Science Education Center
The University of Texas at Austin

Just as a child defined a ceiling as something to hang light fixtures on, Performance Based Teacher Education can be called a way to enable teachers to perform. Is such a strategy of teacher education really different from other models in any important way? Does such a strategy produce teachers who are any more competent to cope with today's classes?

Neither of these questions have final answers, but based on five years of work in a Performance Based Teacher Education prototype, this hour will briefly explore both the characteristics of a Performance Based Teacher Education program and a set of questions as springboards for group discussion.

Session IIb - Teacher Education, Statler 2

Chairman: Delmar Janke, Texas A. & M., College Station, Texas

1. "A Study of the Relationship Between Various Academic and Professional Factors and Selected Elementary School Science Teaching Competencies." David J. Kuhn, University of Wisconsin-Parkside, Kenosha, Wisconsin
2. "Self-Identification as a Tool for Temporary System Evaluation." Glenn H. Crumb, Western Kentucky University, Bowling Green, Kentucky.
3. "The Development of the Skill of Questioning By Prospective Secondary School Science Teachers." Patricia E. Blosser, The Ohio State University, Columbus, Ohio.

A STUDY OF THE RELATIONSHIP BETWEEN VARIOUS ACADEMIC AND PROFESSIONAL FACTORS AND SELECTED ELEMENTARY SCHOOL SCIENCE TEACHING COMPETENCIES

David J. Kuhn
University of Wisconsin-Parkside
Kenosha, Wisconsin

Objectives: The objective of the study was to examine the relationships between various academic and professional factors and the attainment of selected elementary school science teaching competencies.

Methods: The science teaching competencies selected included the ability to: (1) focus a compound microscope, (2) distinguish observations from inferences, (3) construct behavioral objectives, (4) apply Flanders Interaction Analysis, and (5) use set induction techniques. These competencies were selected as being representative of a larger domain of laboratory skills, science process usage abilities and teaching skills necessary for effective elementary school science teaching.

The academic and professional factors measured included: (1) Education Course Grade Average, (2) High School Science Units, (3) University Science Grade Average, (4) Overall University Grade Average, (5) Attitude toward Science, (6) Degrees of Participation in Science-Related Activities, (7) Semester Hours of Life Science and Physical Science, (8) Understanding of Science Processes and (9) the Perceived Difficulty of Science Courses as compared with non-science courses.

The correlations were determined between the various academic and professional factors and the selected science teaching competencies by use of a multiple intercorrelation matrix. The significance of the correlation coefficients was determined at the five and one per cent levels of significance. A similar procedure was used to examine the intercorrelations among the factors. The intercorrelations among the five science teaching competencies were also studied.

Data Sources: The data were drawn from a population of pre-service elementary teachers enrolled in an undergraduate course in elementary science education. The subjects were primarily juniors or seniors. Most had completed their undergraduate science courses and a substantive number of teacher education classes.

Results: The results of the study indicated: (1) significant correlations between the laboratory skill, science process competencies and the understanding of science processes and University science grade average; (2) a significant intercorrelation between the science skill and science process usage and between these abilities and interaction analysis competency; however, the correlations of science laboratory skill and process usage with the other teaching skills were non-significant; (3) a significant correlation between set induction competency and the pre-service teacher's attitude toward science; the correlations with other science-related factors were non-significant; (4) a significant correlation between the understanding of science processes and college science grade average and attitude toward science.

Significance: The findings of this study should aid in the clarification of the role of some of the academic and professional factors that contribute to the development of selected elementary school science teaching competencies. This study may aid science educators in planning competency-based elementary science education programs for pre-service and in-service teachers. It may also form a basis for other studies of the nature of the acquisition of basic elementary school science teaching competencies.

SELF-IDENTIFICATION AS A TOOL FOR TEMPORARY SYSTEM EVALUATION

Glenn H. Crumb
Western Kentucky University
Bowling Green, Kentucky

Objectives: It was the purpose of this inquiry to determine the ability of a group of SCIS Leadership Personnel Workshop participants to (a) identify their own leadership traits or roles and (b) to make use of the theory and practice of temporary system management to develop, through brain-storming techniques, a macro-design for another temporary system.

Method: At the end of a four-week training program participants were presented with a classification scheme for identifying role behavior and asked to classify their own behavior into one of three roles (after Goodson.) Having identified their roles the participants were asked to group themselves according to those roles and develop a macro-design for a temporary system. The output of the three groups was collected by auditing each group and listing in chronological order the items suggested for the macro-design. These items were then correlated to the role identification characteristics unique to each group.

Results: The results suggest that the trainees were able to make use of temporary management theory and practices to develop a macro-design and that the macro-design developed uniquely displayed traits of the specifically identified group of leadership trainees as determined by self-selection.

Significance: The significance of this inquiry relates to the present practices being employed by many NSF sponsored teacher-training workshops in which a multiplier effect is involved. The apparent importance of role identification in selection of staff for planning and conducting teacher-training programs with the ripple effect is pointed up by the results of the inquiry.

THE DEVELOPMENT OF THE SKILL OF QUESTIONING BY PROSPECTIVE SECONDARY SCHOOL SCIENCE TEACHERS: AN EXTENSION

Patricia E. Blosser
The Ohio State University
Columbus, Ohio

Objectives: Asking questions has long been accepted as a teaching technique. One of the current emphases in science education is the use of "inquiry," which implies the use of questions structured to enable students to discover information for themselves rather than to recall information given via a lecture. Teaching methodology advocated as desirable and that actually practiced in classrooms has not always been identical.

This study, an extension of one completed as a doctoral dissertation, was designed to determine the combined effects of duration and timing of instruction in questioning techniques on classroom performance. Three hypotheses were tested:

1. There is no significant effect of duration (massed vs. distributed practice) of the instructional sequence on skill development in questioning.
2. There is no significant trend over time in development of questioning skill.
3. There are no differential effects in treatments across audiotaping sessions for the criterion variables: Open Questions, Pause Time, Teacher Talk.

Methods: Twenty-seven preservice secondary school science teachers were involved in the study which extended over two quarters. Subjects were randomly assigned to three treatment groups: R_1 received instruction in questioning distributed over a fourteen week period; R_2 and R_3 received the same instruction during a seven week period, in quarter one for R_3 and quarter two for R_2.

Data Sources: All subjects were pre-tested, using a fifteen minute microteaching lesson which involved peers as pupils, in quarter one. Lessons were videotaped. In addition, data were gathered by audiotaping three science lessons during quarter two when all subjects were involved in teaching science to elementary school students.

Questions identified from the tapes (video, audio) were made into typescripts. Typescripts and recordings were used for data analysis. Questions were classified, by the investigator, using a category system developed for the doctoral study. Analysis of questioning techniques was limited to randomly selected fifteen minute segments of the lessons audiotaped in the schools, to maintain comparability with the videotaped pre-test lessons.

Data were analyzed by the use of programs for correlation, for step-wise regression analysis, and for multiple analysis of variance.

Results and/or Conclusions: Hypothesis 1 could not be rejected on the basis of data analysis. Hypothesis 2 could not be rejected for the variables of Open Questions and Teacher Talk. Hypothesis 2 could be rejected for the variable of Pause Time. Hypothesis 3 could not be rejected for the criterion variables of Open Quesions and Pause Time. It could be rejected for the criterion variable of Teacher Talk.

Significance: It appeared that, for the group involved in this study, skill development in questioning was best facilitated by moderate to extensive instruction prior to the demonstration of the behaviors in the schools. Review appeared to increase the benefit of prior instruction and audiotaping. If questioning is a teaching skill that does not differ markedly in acquisition from other skills stressed in science methods courses, specifically those skills related to laboratory techniques, the results of this study may support the contention that enrollment of preservice science teachers in methods courses concurrent with student teaching is not an effective way to promote skill development and utilization.

Pre-test data, in which peers were pupils playing the roles of ninth grade students, differed from data on questioning behaviors exhibited in public school classrooms. Extensive use of peers as pupils for lessons designed to promote skill development needs to be investigated relative to problems involved in transferring the skills practiced in these situations to teaching younger students.

Session IIc - Instructional Procedures, Hilton 1

Chairman: Donald Neuman, University of Wisconsin, Milwaukee, Wisconsin

1. "An Assessment of the Effectiveness of Auto-Paced Techniques in Teaching College Physical Geology to Bright Elementary School Age Children." Francis T. Siemankowski, State University College, Buffalo, New York and Stephen Gerenscer, Calasanctius Prep School, Buffalo, New York.
2. "Performance on Tasks of Concept-Attainment Using On-Line Computer Terminals." Thomas E. Smith, Holmdel Public Schools, Deal, New Jersey.
3. "Museum Science Education With Social Integration and Urban Problems As A Focus." David W. Allen, Philadelphia Board of Education, Philadelphia, Pennsylvania.

AN ASSESSMENT OF THE EFFECTIVENESS OF AUTO-PACED TECHNIQUES IN TEACHING COLLEGE PHYSICAL GEOLOGY TO BRIGHT ELEMENTARY SCHOOL AGE CHILDREN

Rev. Stephen Gerencser
Calasanctius Preparatory School
Buffalo, New York

and

Francis T. Siemankowski
State University College
Buffalo, New York

Objectives: Auto-paced learning systems in science are currently used by schools and colleges to provide students a consistently high caliber of instruction in spite of limitations such as inadequately trained staff and small supply budgets. Although this method of individualizing instruction has its pluses, the investigators in this study felt that answers to the questions listed below should be found.

1. Can auto-paced teaching techniques be used effectively in the instruction of high IQ elementary school age children?
2. Is there a significant difference in achievement of young bright children who are closely supervised by a teacher and those whose instruction is independent and directed by tape?
3. Is mode of instruction reflected in attitudes of these students to the subject taught?

Methods: Students participating in the study were forty-seven Second Formers (6th graders) taking physical geology at Calasanctius Preparatory School, Buffalo, N.Y. Admission to the school is based on the student meeting rigorous entrance requirements related to high learning potential. Students, except those coming from minority groups, must attain an IQ score of 130 or higher on the Weschler Scale to qualify. Age range of subjects was 9 to 12 years of age. Three students were randomly selected from each of three physical geology sections and placed in the auto-paced group. Remaining students were taught in the normal classroom environment. The auto-paced group, during the first two months of instruction, met twice weekly with the instructor and received the balance of weekly instruction by means of tape-directed activities. During remaining months the instructor reduced the visits to the independent study center to one a week.

Science topics taught were the same for both treatment groups during the first semester. In the second semester the auto-paced group was permitted to proceed at its own pace without restrictions to topics studied by the control group, to test range of topics it could successfully cover.

Data Sources: Analysis of variance of unit achievement test scores, conducted during the first semester while science content was constant for both groups, showed a significant difference in achievement between groups, favoring the auto-paced group at the .05 level.

The Purdue Attitude Scale administered in September and in the following June showed no significant differences in attitudes toward science in the two treatment groups. Attitudes toward all school subjects were generally lower at the end of the school year but not significantly so.

1. auto-paced teaching techniques can be used successfully in teaching college physical geology to high IQ elementary age students,
2. achievement test scores of students receiving taped laboratory exercises were superior to the control group scores,
3. the mode of instruction had no significant effect on attitude test scores.

Significance: Although results indicate that high IQ elementary age students can learn a college level course in an independent learning environment, further research should be conducted with larger samples to test level of maturity of these students.

PERFORMANCE ON TASKS OF CONCEPT-ATTAINMENT
USING ON-LINE COMPUTER TERMINALS

Thomas E. Smith
Holmdel Public Schools
Deal, New Jersey

Objectives: Individualization of learning activities requires a deep understanding of the interaction of performance characteristics of students with the conditions provided for learning. Data descriptive of the selections made by individuals in the solution of problems may be useful in making inferences about the nature of concept-attainment processes.

This study was designed to identify patterns of selections and performance characteristics displayed by individuals during a concept-attainment task. The relationships between selection patterns and individual characteristics were studied in addition to the effects of changes in task characteristics on selection patterns.

Methods: The selection patterns were identified on the bases of the proportion of positive instances selected by the learner and the sequence of the selections. Selection patterns with a high proportion of positive instances were labeled as analytic and those with both positive and negative instances were labeled as global. Selection patterns in which the learner selected the results of one test solution across all instances before moving to a second test solution were labeled as attribute centered. The selection patterns in which the learner selected the results for all test solutions on one instance before moving to another instance was labeled as instance centered.

The performance characteristics included: (1) the number of selections on each task, (2) the nature (positive or negative) of the first instance selected, (3) median selection time, (4) sufficiency of information at the time of concept identification response, (5) correctness of concept identification response and (6) mean selection time.

The individual learner characteristics included in this study were sex, major field of study and American College Test (ACT) scores.

The task characteristics manipulated by the researcher were: (1) presentation of the instructional tasks in a matrix of linear form, (2) the format of the feedback to the learner during the concept-attainment tasks (matrix or linear), (3) the use of alphabetic or numeric characters to identify the attributes or instances within the concept-attainment tasks and (4) the complexity of the tasks. The complexity was varied by supplying or withholding the number of relevant attributes needed to identify the concept.

Data Sources: The concept-attainment tasks were presented to the learners with an on-line computer teletype terminal. The tasks were programed simulations of the development of a chemical analysis scheme for identifying the presence of a contaminating substance. The learner was asked to identify the chemical tests from those given which might be used to determine the presence of the contaminating substance. The learner was free to request the results for the combination of any test solution (attribute) with any of the unknown solutions (instances). The combination and sequence of these requests represent the selection patterns.

The tasks were administered to two hundred elementary teacher education majors and thirty-seven secondary science teacher education majors at The Ohio State University during the Spring Quarter 1972. The learners were randomly assigned to two phases of the study: Phase I to determine if selection patterns could be identified and Phase II to determine if selection patterns could be changed by changing task characteristics.

Results: An analysis of variance of the selection patterns and the performance characteristics of the learners in Phase I produced significant differences between individuals at the 0.001 level and no significant differences within individuals across similar tasks. These results were interpreted as evidence supporting the hypothesis that different selection patterns are used by learners in concept-attainment tasks. These patterns were identified as (1) analytic-attribute centered, (2) analytic-instance centered, (3) global-attribute centered and (4) global-instance centered.

An analysis of variance of the selection patterns and performance characteristics of the learners in Phase II resulted in no significant differences between means of eight treatment groups with varying task characteristics. These results were interpreted as evidence of the selection pattern stability. Trends in the data which were not significant suggest that knowing the number of relevant attributes may have made the tasks easier and that the learners who receive feedback during a concept-attainment task of this kind in matrix form can be shifted towards an analytic style.

Significance: The design of instructional materials and learning activities should include considerations for differences in individual selection patterns. If further research finds evidence that certain patterns are more efficient than others then the possibilities of modifying selection patterns of learners should be investigated.

MUSEUM SCIENCE EDUCATION WITH SOCIAL INTERGRATION AND URBAN PROBLEMS AS A FOCUS

David W. Allen
Philadelphia Board of Education
Philadelphia, Pennsylvania

Objectives: Out-of-School Science Experiences for Paired Schools, commonly called the Paired School Science project (PSSP), brings sixth-grade children from pairs of schools having varied racial and socio-economic backgrounds to the Franklin Institute for physical and biological science lessons one day a week over a six-week cycle, including relevant afternoon field trips.

This year's evaluation dealt with the following questions about the project:

1. Has PSSP provided the conditions that are considered prerequisite for the attainment of its objectives?

2. Have changes in the project been implemented?

3. Have PSSP pupils demonstrated knowledge and understanding of basic concepts of science?

4. Has a reduction in social isolation occurred as a result of the pairing of schools having pupils from different ethnic backgrounds?

Methods: A measure of attitudes was used to evaluate the project's achievement of its attitudinal objective and some sociometric observations were made. Attendance and interaction between paired school pupils were monitored and teachers were asked whether they felt the pairing of pupils from different schools was constructive.

Data Sources: Various PSSP activities (e.g., laboratory investigations, demonstrations, and classroom discussion) were systematically monitored with the use of the Observational Checklist, during each cycle of the project. Data from the observations were recorded in terms of frequency.

The new PSSP activities (e.g., field trips) were systematically monitored with the use of the Observational Checklist, during each cycle of the project. Data from the observations were recorded in terms of frequency.

A revision of the Science Achievement Test was undertaken during the first three cycles: two forms, A and B, were developed (Form A, reliability coefficient .78, KR-20; Form B, reliability coefficient .75, KR-20), which were especially designed to measure cognitive learning resulting from the

Franklin Institute experiences. In evaluation progress in the fourth cycle, students were administered on a randomly determined basis either Form A or Form B as a pretest. The alternate form of the science test was administered to each class as a posttest.

A sociometric instrument, "Six American Twins On A Bus," designed to measure changes in attitude, was administered before and after the pupils' six-week experience at Franklin Institute. This was supplemented with direct observation using sociograms and an interview with the participating teacher.

Results: Consistently favorable conditions were found, using data obtained through systematic monitoring of PSSP activities.

Data obtained through systematic monitoring of PSSP activities indicated failure to achieve all the desired conditions, inferring some difficulty in implementing the changes.

A t test of the difference indicated that the gain score from pretest to posttest for the Science Achievement Test was significant (p .01).

The pretest-to-posttest changes in attitude toward a person of another ethnic group were not statistically significant, as shown by data from the attitude instrument, "Six American Twins On A Bus."

A summary of the results of sociometric interactions indicates that pupils interacted socially from the paired schools and that there were differences in the amount of interaction depending on the particular pairing of schools.

Interviews with six PSSP cooperating teachers indicated that five of the six perceived the pairing of pupils from different schools as having high social value. The 91% average daily attendance for the project tends to confirm that the PSSP pupils enjoyed their Franklin Institute experiences.

Significance: PSSP has provided the conditions that are considered prerequisite for the attainment of its objectives. Systematic monitoring has yielded consistent results: appropriate materials have been available and used; instructors have been fulfilling their specified roles appropriately; and pupils have been attentive during the PSSP activities.

The desired conditions were not consistently fulfilled in the extended afternoon program involving field trips. The pupils, however, were attentive and thought the field trips were educational.

PSSP pupils have demonstrated knowledge and understanding of basic concepts of science. Their mean score from pretest to posttest indicated a significant gain. Thus one may conclude that the pupils improved their knowledge of the physical and biological sciences during their six days at the Franklin Institute.

Session IId - Learning Theory, Hilton 3

Chairman: Ronald Raven, State University of New York, Buffalo, New York

1. "The Development and Use of the Science Process Skill of Prediction." Robert P. Thiel, Southern Connecticut State College, New Haven, Connecticut.
2. "The Performance of Children on Visual Observation and Comparison Tasks." James P. Barufaldi, The University of Texas at Austin, Austin, Texas.
3. "Evaluation of the Science Process Skills of Observation and Classification." Rajinder Kaur and James R. Campbell, University of Pennsylvania, Philadelphia, Pennsylvania.

THE DEVELOPMENT AND USE OF THE SCIENCE PROCESS SKILL OF PREDICTION

Robert P. Thiel
Southern Connecticut State College
New Haven, Connecticut

Objectives: The purposes of this study were: 1) to identify those factors that significantly affect the use of the science process skill of prediction, and 2) construct and test a competence-performance model that accounts for performance on tasks involving the skill of prediction.

Methods: Based on a review of the literature on skill development, four factors were identified that may effect a student's performance on tasks involving the skill of prediction. These factors were; a) the student's grade level, b) the type of rule (seriation or classification) used in the task, and d) the number of attributes in the task. Six tasks involving the skill of prediction were constructed by the investigator. These tasks were administered to 90 students in grades three, four, and five. These students were defined, on their performance on three Piagetian tasks, to be concrete operational. The tasks were administered to the students in a one to one situation. This sample was used to test the significance of the factors previously identified.

An independent sample of twenty-six students from grades four and five were given the six prediction tasks. These students, also defined to be concrete operational, served as the sample to test the investigator's model to account for the student's performance on the prediction tasks.

Data Sources: The performance of each subject on each task was used to define the subject's probability of passing the task. The probabilities of the ninety subjects of the first sample were analyzed using a four factor analysis of variance. The type of rule and number of attribute factors constituted repeated measures on the subjects since these factors varied over the six tasks. These data were also used to define the intrinsic difficulty of each task.

Results: The factors that significantly affect the subject's performance on the tasks were the type of rule and the number of attributes in the task. Since these factors were task related, it was concluded that task related variables should be accounted for when activities are given to children for the purposes of evaluation of skill ability. It also implies that existing tests measuring basic science skills should be reanalyzed in terms of intrinsic item factors. The non-significance of the subjects grade level implies that skills may develop in the same manner when subjects are concrete operational.

Significance: The investigator's model was shown to account for the subjects performance on the prediction tasks. The model may serve as a general equation to assign quantatative values to the child's various skill ability. More work, however, is necessary to expand the model to non-concrete operational children.

THE PERFORMANCE OF CHILDREN ON
VISUAL OBSERVATION AND COMPARISON TASKS

James P. Barufaldi
The University of Texas at Austin
Austin, Texas

Objectives: The purpose of this study was to investigate the effects of different types of visual stimuli (solid objects, photographs, and drawings of the objects), grade level (mean age), and sex of the subjects and the interrelationships of these factors on the performance of children on visual observation and comparison tasks focusing upon the four physical attributes of color, size, form, and form-detail.

Methods: The students selected for this study were from two urban elementary schools with a racial composition of 99% Black and 1% Oriental and others.

Two solid objects; a cube and a cylinder, were constructed; two representations of the objects (photographs and drawings) were prepared; and fourteen visual observation and comparison tasks were written, using the objects as a frame of reference. The tasks focused upon the physical attributes of color, size, form, or form-detail. The tasks were orally administered to subjects in grades one, two, four, and six in groups of twenty in the same grade at a time. The children, each of whom made observations and comparisons of one of the types of visual stimuli, responded on specially prepared answer sheets. All tasks were weighted equally with a score of 1 assigned to correct responses and 0 to incorrect responses.

Data Sources: Within grades one, two, four, and six means and standard deviations of the number of correct responses on the color, size, form, and form-detail observation and comparison tasks were calculated. Analyses of variance and post-hoc comparisons were also performed on these scores. An overall measure of task reliability, Kuder Richardson No. 20 was within the range of .468 to .757 for all grades.

Results: From the statistical analyses carried out in this study, the following conclusions are drawn:

1. The different types of visual stimuli affect the performance of children on visual observation and comparison tasks which focus upon the physical attributes of form or form-detail. Children perform more successfully (make more correct responses) on these tasks when they observe and compare either the solid objects or the photographs of the objects than do those children who observe and compare the drawings of the objects. The different types of visual stimuli do not affect the performance of children on visual observation and comparison tasks which focus upon the physical attributes of color or size.

2. The grade level of the children affects their performance on visual observation and comparison tasks which focus upon the physical attributes of color, size, form, or form-detail. The older the children, the more successfully they perform these tasks.

3. Differences in sex affect the performance of children on the visual observation and comparison tasks which focus upon the physical attribute of color. Females perform these tasks more successfully than the males. The difference in sex does not affect the performance of children on the visual observation and comparison tasks which focus upon the physical attributes of size, form, or form-detail.

Significance: The educational implications of this study focus on the selection of appropriate teaching materials and methods. The teacher should consider, in the selection of methods and teaching materials, the sex and grade level of the individual child in relation to the effect of different types of visual stimuli on his performance of certain tasks. The choice of the physical attributes of color, size, form, and form-detail among teaching materials should also be done with consideration for characteristics of and differences among sexes and grade levels.

EVALUATION OF THE SCIENCE PROCESS
SKILLS OF OBSERVATION AND CLASSIFICATION

Rajinder Kaur
and
James R. Campbell
University of Pennsylvania
Philadelphia, Pennsylvania

Objectives: The purpose of this investigation was to develop an instrument to evaluate the science process skills of observation and classification of children in grades one and three, and to determine the relationship between these skills. The test was designed after reviewing several different elementary school science programs. The skills were defined in terms of the behavior required to carry out each task. Test items were designed to conform to these specifications by using familiar and non-familiar objects by the Classification Skills Test (CST) and Precise Observation Skills Test (POST) respectively.

Methods: A sample number of test items was administered to a small group of first, second, and third grade students. This administration indicated that these items elicited the stipulated behavioral responses. Prior to this administration, the test was presented to a panel of three science educators for the purpose of establishing judgmental validity. Those items which the three judges unanimously affirmed as consistent with the skill definitions and with the performance criteria were retained in the test. Two items were removed from the POST to shorten the test sufficiently to reduce the fatigue factor. The remaining eight items on POST and five items on CST composed the final form of the test. These thirteen items were used to determine the reliability of the test.

Data Sources: Final testing was done on an individual interview basis. The scope of this investigation was restricted to a population of 80 boys, 40 from grade one and 40 from grade three attending an elementary school in a suburb of Philadelphia.

Results: The findings and conclusions of the study were as follows: Reliability on POST was .86 for grade one and .94 for grade three. Reliability on CST was .59 for grade one and .62 for grade three. Reliability coefficients were determined by K-R 20 and significant differences between the mean scores were determined by the t-test. For both grades combined, the correlation coefficient between the POST and CST was found to be .86.

The statistical analyses suggested that a maturity factor was involved in using observation skills, grade three boys described the objects in greater precision than grade one boys. Classification skills of grade one and grade three were not significantly different.

The results of this study add to the evidence that a strong relationship exists between the skills of observation and classification. The study also suggested that the ability to make precise observations using different senses is age related; grade three boys exhibited a higher level of performance in making fine discriminations than grade one boys.

Significance: The POST and CST would provide the teacher with a diagnostic instrument to evaluate the pupil's present level of performance and would also provide information to design curriculum activities for different age and ability levels. A vital part of these interviews is the opportunity for the investigator to observe and record the child's understandings. Although time-consuming, the use of individual interview seems to be a promising method for evaluating the developmental pattern of these skills and child's intellectual growth at the primary grade levels.

Within the limitations of this investigation, the results and conclusions suggest that further research is needed to design analytic tools, to evaluate the development of observational and classificatory skills of children of different ages, sexes and socioeconomic levels.

CONCURRENT SESSION III

Session IIIa - A Discussion Paper, Statler 1

Chairman: Roger L. Wood, University of Wisconsin, Stevens Point, Wisconsin

1. "Pattern Analysis - A Macroscopic Development for Interaction Analysis." James R. Campbell, University of Pennsylvania, Philadelphia, Pennsylvania.

PATTERN ANALYSIS - A MACROSCOPIC DEVELOPMENT FOR INTERACTION ANALYSIS

James R. Campbell
University of Pennsylvania
Philadelphia, Pennsylvania

Objectives: Has interaction analysis failed to advance educational methodology? Why have advances failed to materialize in this potentially productive area? More important, why have efforts to disseminate interaction analysis to the classroom teacher been unproductive? It is the contention of this author that the answer to all three questions concerns the much-touted interaction matrix. The matrix has been used as the primary vehicle for summarizing sequenced data. It has been productive to researchers for the many ratios derived from it but has failed to generate new directions for research and has been a poor device for dissemination. The primary problem appears to be the sequencing unit used to construct the matrix. This two-unit sequencing reduces all analyses to very small time units. Such reductions literally turn interaction data into "Microscopic units" which are too limiting for subsequent analysis or feedback.

In an attempt to overcome this obstacle Hall[1] and the Amidons[2] derived an ingenuous mechanism for extrapolating longer sequences from the two-by-two matrices. Patterns of three or four categories resulted. In many cases such patterns did produce major insights into the methodology employed. Unfortunately, such analyses did make inferences beyond the data and in some cases the resulting patterns simply did not exist. Furthermore, no mechanism was derived for incorporating the "steady state cells" into the patterns without overly complicating the analyses.

Methods: In order to overcome these difficulties macroscopic analysis was developed. This procedure involves a computerized program which scans the total number of interactive tallies and simply tabulates the existing chains of categories or patterns. To date, macroanalysis programs have been developed which uncover three category chains, four category chains, and five category chains.

Data Sources: In order to demonstrate how macroanalysis is used we have taken the interactive data from a study involving ten junior high teachers and applied the macroscopic analyses to the two treatment groups. Each teacher was audio-recorded and analyzed according to the Campbell-Rose Interaction System (CRIS) for his highest and lowest ability group. The mean IQ for the high group was 114.7 while the mean IQ for the low group was 89.50.

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[1] G.E. Hall, The Instrument for the Analysis of Science Teaching: A System for Measuring Behavior, Austin, Texas: The Research and Development Center for Teacher Education, 1969.

[2] E. Amidon and P. Amidon, Teaching Pattern Analysis Manual, Minneapolis, Minnesota: Association for Productive Teaching, 1967.

Results: Macroanalysis produced a mean of 539 three category patterns; 913 four category patterns, and 1208 five category patterns per teacher. When all ten teachers' interactive data was summed for both groups, macroanalysis uncovered a mean of 2465 three category patterns; 5826 four category patterns; and 9297 five category patterns. (2) Individual teachers used only 10.8 percent of the maximum number of three category patterns possible; only 3.70 percent for four category patterns and only .98 percent for five category patterns. These findings show that teachers in widely differing groups utilize only a small percentage of the potential variety of patterns. (3) Despite significant differences between the groups for numerous interactive ratios, the predominant patterns used in the groups are largely similar. Major differences, however, do occur in the high ability groups in such areas of indirectness, high level teacher questioning, high level student participation, wait-time and silence. In most cases, teachers in the high ability groups introduced a small number of specific patterns to adjust their indirectness or to increase the cognitive level of the group. Likewise, in the low ability group teachers adjusted their disciplinary behavior by emphasizing specific disciplinary patterns. (4) The interactive ratios of the two ability groups showed that the high ability group received a significantly more indirect approach.

Further analyses will contrast the results of the study in terms of the traditional interactive matrices and ratios and the macroscopic chains.

Significance: The position taken in this paper is that the macroanalysis chains will enable researchers, supervisors, and teachers to readily understand how to translate interactive methodology into classrooms. This development may enable researchers to experiment with specific interactive models, it may also enable teacher-training institutions to use patterns in microteaching or in behavioral laboratories. Hopefully, the simplicity involved in the macroanalysis process will provide new directions for research and dissemination in the areas of teacher behavior, teacher effectiveness, and particularly in the development of an instructional feedback mechanism for inservice and preservice training.

Session IIIb - "An Hour With" Session - Statler 2

Chairman: George T. O'Hearn, University of Wisconsin,Green Bay, Wisconsin

"An Hour With John J. Koran, Jr. About Learning Research in Science Education: Some Promising Areas"

John J. Koran, Jr.
University of Florida
Gainesville, Florida

The intent of this seminar is to stimulate discussion and debate about a number of areas of science education research. Brief introductory statements will be made about the following areas: 1) research on observational learning; 2) mathemagenic research; 3) pictorial research; and 4) aptitude treatment interaction research. Effort will be made to stimulate discussion about the theoretical basis for research in these areas, and to identify promising directions for future research. Beginning science educators working in some of these areas will be invited to briefly describe their research activities. Examination of the following literature will provide a common basis for discussion:

Dwyer, Frances M., *A Guide for Improving Visualized Instruction*, State College, Pennsylvania: Learning Services, 19[illegible].

Frase, Lawrence T., "Boundary Conditions for Mathemagenic Behaviors" *Review of Educational Research*, Vol. 40, No. 3, June 1970.

Koran, John J. Jr. "The Use of Modeling, Feedback and Practice Variables to Influence Science Teacher Behavior" *Science Education*, 56, (3), 1972a, 285-291.

Koran, John J. Jr., "How Can Elementary Students and Teachers Be Models of Scientific Process" *Science and Children*, 9, (7) 1972c.

Koran, Mary Lou, "Varying Instructional Methods to Fit Trainee Characteristics" *AV Communication Review*, Vol. 20, No. 2, Summer 1972.

Session IIIc - Instruction, Hilton 1

Chairman: Robert B. Collagan, Morgan State University, Baltimore, Maryland

1. "A Study of the Teaching of Observational Skills for Environmental Science." Felecia E. West, Gaithersburg, Maryland and Thomas Gadsden, Jr., University of Florida, Gainesville, Florida.
2. "An Investigation of Two Formal Operational Schemata in Adolescents Enrolled in the I.S.C.S. Classrooms of Three Selected Teachers." James P. Hale, Glencoe Public Schools, Glencoe, Illinois.
3. "An Evaluation of the Effectiveness of Narrative Reading Materials in Science Teaching." Leonard I. Kindler, John Bowne High School, Forest Hills, New York.

A STUDY OF THE TEACHING OF OBSERVATIONAL SKILLS FOR ENVIRONMENTAL SCIENCE

Felecia E. West
Gaithersburg, Maryland

and

Thomas Gadsden, Jr.
University of Florida
Gainesville, Florida

Objectives: This study, conducted at P. K. Yonge Laboratory School of the University of Florida as a part of its research and development function, had two primary objectives. The first was to test the practicability of an instrument developed by the authors to measure the effects of indoor and outdoor activities in bringing about changes in observational skills of students in environmental studies classes. The second objective was to obtain information concerning the effectiveness of a unit developed for the purpose of increasing environmental awareness through improvement of observational skills.

Methods: The instrument consists of two separate tests. In the first (Test A) students view and record their observations of a series of fifteen slides depicting nature scenes, animals, people, man-made constructions, and environmental problems. The second instrument (Test B) requires students to observe and record within the natural setting of one of several measured plots of land. In both cases allotted time is carefully controlled.

The instrument was used in conjunction with a treatment which consisted of three, two-hour walking field trips emphasizing field observation of specified types of things and seven intense but brief in-class observational tasks which were graded in difficulty and complexities.

Data Sources: The instrument was administered to fifty-five experimental and twenty-five control students according to the following design:

Experimental Group 1	R	O_A	X	O_B
	R	O_B	X	O_A
Experimental Group 2	R		X	O_A
	R		X	O_B
Control Group # 3	R	O_A		O_B
	R	O_B		O_A

Assignment to experimental or control groups was by self-selection, but assignment of testing was done randomly.

Results: Initial analysis indicated that the instrument does provide the evaluative information and that it can be a valuable tool in assessing growth in observation abilities relative to environmental studies. However, a practical difficulty encountered in administering the instrument was that extensive preparation time was required for its proper use.

These initial results also provide information that could lead to a model of levels of awareness which could provide a more useful framework for the teaching of observational skills. Further analysis will be needed to determine the effectiveness of the treatment unit.

Significance: The teaching of science, especially enviromental studies, without reference to students' awareness of the natural phenomena they are studying is often an exercise in futility. This is one of the most basic skills with which we must be concerned. This study provides a method of evaluating success in teaching this skill, and a theoretical framework which will be of use in designing or improving other units concerned with observational skills.

AN INVESTIGATION OF TWO FORMAL OPERATIONAL SCHEMATA IN ADOLESCENTS ENROLLED IN THE I.S.C.S. CLASSROOMS OF THREE SELECTED TEACHERS

James P. Hale
Glencoe Public Schools
Glencoe, Illinois

Objectives: The purpose of this study was to investigate the development of two logical schemata in adolsecents enrolled in three selected Intermediate Science Curriculum Study (I.S.C.S.) test center classrooms.

Methods: Four formal level Piaget-related tasks were developed for use in this study. Two tasks, Inclined Plane and Hydraulic Press, were developed to reflect the logic associated with Inhelder and Piaget's (1958) formal logical schemata, mechanical equilibrium. Two other tasks, Switches and Colored Beads, were developed to reflect the logic associated with Inhelder and Piaget's (1958) formal logical schemata, combinatorial operations. The Inclined Plane and Switches tasks were chosen because they consisted of Level I, I.S.C.S. course-related content. The Hydraulic Press and Colored Beads tasks were chosen because they contained content which the author considered non I.S.C.S. neutral. Associated with this purpose was a general description of the personal and professional background and in-class behavior of the three teachers of the selected I.S.C.S. classrooms.

Data Sources: One hundred eight randomly-selected eighth grade students, thirty-six from each test center, were utilized in this study. Each student was interviewed utilizing the four Piaget-related tasks. The Level I, I.S.C.S. teacher for each of the eighth grade students selected was also interviewed, utilizing a biographical data sheet. Each test center teacher's classroom was visited on several occasions and on two specific occasions the Science Curriculum Assessment System (S.C.A.S.) interaction analysis system was utilized to collect teacher behavioral data.

All data and observations concerning the students and teachers were collected during the second semester of the 1971-72 academic year. Both quantitative and descriptive data were collected during the course of this study.

The quantitative data were statistically analyzed in the areas of: (1) the main and interaction effects of the Piaget-related task scores and sex of subjects, with the I.T.B.S. scores as the criterion measure; (2) the differences between the Piaget-related task scores for each of the three test center populations; and (3) the difference in performance on the I.S.C.S. course-related tasks and the neutral tasks for the three test center populations and the total population.

The descriptive data were in the areas of: (1) the students' Piaget-related task scores; (2) the comparative analysis of the students' I.T.B.S. scores and the Piaget-related task scores; and (3) the personal, professional and behavioral characteristics of each of the three test center teachers.

Results: Three major conclusions can be drawn from the analyses reported in this study. A majority of the thirteen and fourteen year old students tested in this study were classified either as concrete operational (a score of 2) or as transitional formal operational (a score of 3) on the four Piaget-related tasks. Secondly, students whose I.T.B.S. scores fell in the lower half of the score distribution of the I.T.B.S. Reading Comprehension test and the Composite are not necessarily poor thinkers (as defined by a score of four on one or more of the Piaget-related tasks). Conversely, students whose I.T.B.S. scores fell in the upper half of the score distribution of the I.T.B.S. Reading Comprehension test and Composite are not necessarily good thinkers (as defined by a score of zero or one on one or more of the Piaget-related tasks). Thirdly, the students utilized in this study performed better on the non course-related neutral Piaget tasks than on the course-related tasks.

Significance: Three inferences were made. (1) Formal operational thinking as measured by the four tasks presented in this study, has not manifested itself to any significant degree in the adolescents included in this study. (2) Commonly used achievement tests did not necessarily describe a student's abilities to the fullest extent. The Piaget-related tasks may be effectively utilized along with the achievement tests to describe these abilities better. (3) The appropriateness of the Level I, I.S.C.S. content for seventh grade students can be tentatively questioned. Based upon the course-related and non course-related comparisons in this study, Level I, I.S.C.S. may contain intellectually inappropriate material for this age child.

AN EVALUATION OF THE EFFECTIVENESS OF NARRATIVE READING MATERIALS IN SCIENCE TEACHING

Leonard I. Kindler
John Bowne High School
Forest Hills, New York

Objectives: The objective of this inquiry was to determine the relative effectiveness of narrative and expository (i.e., standard textbook) passages in developing immediate and retained cognitive abilities in science students.

Methods: Two passages equivalent in length, readability, and topic difficulty were selected from a ninth-grade general science textbook. The two passages were on different topics ("sound" and "motion"), so that the content of one passage would be essentially unrelated to the content of the other. Then, two narrative passages were written on the same topics, matching the expository passages in content, length, and readability, but in the form of a story of some intrinsic interest. Thirty-six test items on each topic were selected by item-analysis from an original group of forty items based on the content of the passages. These items were written to test those cognitive abilities classified in Bloom's Taxonomy of Educational Objectives under the headings of 1.00 Knowledge, 2.00 Comprehension, and 3.00 Application.

The experimental subjects were the (approximately 200) students enrolled in the ninth-grade general science course at a public high school in New York City. After a pre-test,to determine their pre-existing level of cognitive abilities, half of the students read a narrative passage, while the other half read an expository passage, on a different topic. All of them were given a test of their cognitive abilities immediately after reading a passage. Each student then read a passage on a different topic, and in the "opposite" form, and was then tested for the effect of that passage on his cognitive abilities. Four weeks later, without further exposure to the passages, the subjects were re-tested, as a measure of retention.

Data Sources: A "net change" (test minus corresponding pre-test) score was calculated for each student, after reading each form of passage, for both immediate effect and for retention. The mean "net change" after reading a narrative form of presentation (for all subjects) was compared to the mean "net change" after reading an expository form of presentation, using the t-test for correlated means. The same t-test was also carried out with various sub-groups, obtained by stratifying the sample with respect to selected objective criteria.

Results: The mean increase in cognitive abilities immediately after reading a narrative passage was significantly greater than the mean increase immediately after reading an expository passage for two sub-groups within the sample: girls, and those students whose general science grades at the end of the semester were above the mean of their classmates. After four weeks, the narrative form of presentation resulted in significantly greater retention of cognitive abilities by two different sub-groups: students below the mean age of the sample, and students who lived in a predominantly black, low-income area of the city. No sub-group showed any greater mean gain in cognitive abilities after reading an expository form of presentation than after reading a narrative passage, for either immediate effect or for retention.

Significance: Since narrative materials are often intrinsically interesting, especially to younger children, and therefore self-motivating, it is reassuring to know that such materials can develop the sort of cognitive abilities that the usual, expository textbook is supposed to develop. The use of narratives in science teaching should be studied and attempted more extensively, especially with students who do not respond well to the more conventional textbook.

Session IIId - Teacher Behaviors, Hilton 3

Chairman: Roger Olstead, University of Washington, Seattle, Washington

1. "Change in Predicted Teacher Behavior Based on Experience With An Activity Oriented Elementary Science Course." Carl B. Berger, University of Michigan, Ann Arbor, Michigan.
2. "Verbal Behaviors Occurring in Biology Classes Engaged in Inquiry Learning." Delivee L. Wright, University of Nebraska, Lincoln, Nebraska.
3. "The Relation Between the Earth Science Curriculum Which a Teacher Elects to Teach and the Teaching Procedures Which He Employs." James R. Orgren, State College at Buffalo, Buffalo, New York.

CHANGE IN PREDICTED TEACHER BEHAVIOR BASED ON EXPERIENCE WITH AN ACTIVITY ORIENTED ELEMENTARY SCIENCE COURSE

Carl B. Berger
University of Michigan
Ann Arbor, Michigan

Objectives: Groups of teachers of elementary school science were compared on their predicted behaviors in order to study the influence of N.S.F. teacher training institutes for and experience with the Science Curriculum Improvement Study (SCIS) teaching strategies. Groups compared had no experience or exposure, an N.S.F. institute only,and an N.S.F. institute and at least one year's experience with the SCIS materials.

Methods: The device used to compare these groups of teachers was the Predicted Role Measure which involved a film of elementary school classroom scenes and a pamphlet of response sheets. When the teacher in the film was to make a decision, the film was stopped and the participants were asked to respond by rating their agreement to behaviors they might exhibit if they were the teacher in the film. Responses were scored using a summated rating technique. Scores were separated into three categories under a theoretical consideration of teaching behavior strategies proposed by SCIS.

The three categories, in essence, were (1) a teacher-oriented score where participants showed their agreement or disagreement with behaviors such as the teacher telling the children the answer or where to find the answer, (2) a student teacher cooperation score where teacher and student cooperate to find the answer to the problem, and (3) a student-oriented score where the teacher allows the student to make a decision in the class.

Participants using the measure could answer independently on each item and were instructed to treat each response separately. The Predicted Role Measure met the following criteria; it reflected a variety of situations, it was specific enough to provide common input, it reflected actual teaching decisions rather than broad attitudes and it reflected and discriminated between the differing teaching behaviors as described by the SCIS curricula.

Split halves reliability was established at 0.84 and a comparison of predicted behaviors to actual observed classroom behaviors established a validity of 0.74.

Data Sources: The groups selected for study included 51 teachers not exposed to SCIS, 69 teachers not exposed to SCIS but starting an SCIS institute, 76 teachers who completed a two or four week NSF institute in the SCIS program and 45 teachers who had completed a four week institute and had taught the SCIS Curriculum for at least one year.

Results: Generally there was a positive correlation between experience of teachers with the SCIS program and their degree of agreement of the SCIS criteria judging group. Specifically there was no significant difference at $\alpha = .01$ between the scores of the 59 no-SCIS instruction group and the 69 pre-SCIS instruction group as measured by a multivariate analysis of variance. (So chosen because of the multiple correlation of scores within the measure.) There was a significant difference in the Predicted Role Measure scores between pre-institute teachers and post-institute teachers. Multiple Contrast intervals indicated that this difference was primarily due to the teacher emphasis scores. Post-institute teachers were less teacher oriented in their responses than pre-institute teachers. Post-institute teachers and post-institute teachers with one year experience teaching SCIS did not differ significantly in their responses to the Predicted Role Measure. Multivariate regression analysis was used to detect if any background variables were significantly correlated with the Predicted Role Measure scores. Variables of age, sex, years of teaching experience, grade level taught, enjoyment of teaching science, number of years college science and number of science methods courses were analyzed. Only two variables of themselves were significantly related to the Predicted Role Measure scores. The enjoyment of science teaching was inversely related to the Teacher Emphasis score and the number of years of college science courses was inversely related for the Teacher Cooperation score. An overall multivariant F indicated that these individual correlations were not strong enough to cause an overall significant effect. It was concluded that there was no relationship between the background variables and the scores on the Predicted Role Measure.

Significance: Selected teachers who experience the N.S.F. institutes in SCIS and/or teach the SCIS curriculum were found to change their predicted teaching behaviors in the direction of the SCIS staff judging group. With experience and training, it may be possible to change teaching behavior toward a criterion goal.

VERBAL BEHAVIORS OCCURRING IN BIOLOGY CLASSES ENGAGED IN INQUIRY LEARNING

Delivee L. Wright
University of Nebraska
Lincoln, Nebraska

Objectives: To objectively determine changes in verbal behaviors occurring in biology classes after the teacher has engaged in a staff development program in inquiry.

Methods: Verbal student and teacher behaviors were analyzed in the classrooms of 10 BSCS teachers who were engaged in the Instructional Staff Development (ISD) Program in Inquiry. This program was developed over a three-year period by the University of Nebraska, (Lincoln) Teachers College as a product of the Mid-Continent Regional Educational Laboratory's Development of Inquiry Skills component.

During the period of one year, each of the BSCS teachers was videotaped before instruction in the ISD program, after instruction, and at two intermediate points during instruction. Verbal behaviors were coded in terms of:

(1) The ten categories of Flander's Interaction Analysis (IA);
(2) A thirty-four subcategory system for analyzing verbal behaviors (The Inquiry Analysis System);
(3) A three-column instrument for analyzing teacher and student verbal behaviors concurrently with the Cognitive Inquiry Behaviors (formulation of the problem, formulation of hypotheses, collection of data, drawing tentative conclusions, assessing, etc.); and
(4) The ten category Affective Behaviors Instrument for coding affective verbal behaviors which promote inquiry.

Coders recording behaviors had consistency in coding of 80% or higher.

Data on verbal behaviors were analyzed in terms of: (1) Ratios and Percentages of IA Categories, (2) Ratios and Percentages of IAS Categories, (3) Ratios and Percentages of Student Talk Categories, (4) Frequency and Variety of Cognitive Behavior Categories, and (5) Frequency and Variety of Affective Behavior Categories.

Data Sources: Data were collected in one randomly selected classroom of each of the ten BSCS biology teachers. These participants taught in schools in the Lincoln and Omaha, Nebraska, areas and had indicated interest in improving their inquiry teaching strategies by enrolling for six hours of University credit in the ISD program.

Results:

1. Flanders I/D ratio increased until classwork became more student-centered; it then decreased again.
2. The total use of facts decreased although students increased the percentage of time they dealt with facts.
3. Percentage of student talk increased with a corresponding decrease of teacher talk.
4. The frequency and variety of both cognitive and affective inquiry behavior categories increased.

Significance: These data support the hypothesis that the ISD Program in Inquiry does produce changes in student and teacher behaviors in the direction of inquiry. The study also provides data for formulation of a model of verbal cognitive and affective behaviors for more effective inquiry.

THE RELATION BETWEEN THE EARTH SCIENCE CURRICULUM WHICH A TEACHER ELECTS TO TEACH, AND THE TEACHING PROCEDURES WHICH HE EMPLOYS

James R. Orgren
State College at Buffalo
Buffalo, New York

Objectives: A new Regents Earth Science Syllabus was adopted by New York State in the fall of 1971. The new syllabus is distinguished from the earlier version by its inquiry orientation and emphasis on laboratory instruction.

One year prior to its mandated adoption, teachers could adopt the new syllabus on a voluntary basis. Thus, during the year 1970-71, both versions of the Regents Earth Science Syllabus were being taught in New York State.

Like several of the newer science curricula, the new Regents Earth Science Syllabus sought to influence the mode of instruction used in science classrooms. The purpose of this study was to determine if instructional procedures employed by teachers using the new syllabus differed from those employed by those using the old syllabus.

Methods: With the cooperation of the State Department of Education, letters were sent to the Regents Earth Science teachers of New York State, seeking their cooperation in the projected study. From those responding, one hundred eighteen teachers were selected to participate in the study. One third of them had experience with the new syllabus during its period of development; one third of them had volunteered to use the new materials for the first time during the year 1970-71; one third of them were continuing to use the old syllabus during 1970-71.

In May of 1971, a modified version of Kochendorfer's Biology Classroom Activity Checklist was completed by one section of students for each of the teachers in the study. It was hypothesized that students of teachers using the new syllabus would report that their teacher employed teaching behaviors more in accord with the new syllabus than those used by teachers of the old syllabus. It was further hypothesized that teachers having prior experience with the new syllabus would use practices more in accord with the new materials than would teachers using them for the first time.

Classroom means on the Activity Checklist were obtained for each teacher in the study. The Planned Comparisons form of Analysis of Variance was used to compare the means of the teachers using the old syllabus with those of the teachers using the new syllabus; the means of teachers using the new materials for the first time were compared with those of teachers having prior experience with the new materials.

Results: It was found that teachers using the new syllabus were reported to use classroom procedures significantly more in accord with the new syllabus than those reported for teachers using the old syllabus. There was no significant difference in teaching procedures between the two groups using the new syllabus.

Significance: These findings suggest that teachers who elect to use a new science curriculum employ teaching procedures more in accord with the objectives of the new curriculum than teachers who elect to use more traditional materials. It leaves for further study the attempt to determine if teachers change their teaching behaviors when they are asked to adopt a science curriculum which promotes such a change.

CONCURRENT SESSION IV

Session IVa - Symposium - The Buffalo Caucus, Hilton 1

"Models for Research and Communication in Science Education"

Chairman: Kathryn J. Beam

Participants: Kathryn J. Beam, Buffalo State University College, Buffalo, New York

Rodney Doran, State University of New York at Buffalo, Buffalo, New York

Joyce Swartney, Buffalo State University College, Buffalo, New York

Francis Siemankowski, Buffalo State University College, Buffalo, New York

Darrell D. Young, Buffalo State University College, Buffalo, New York

MODELS FOR RESEARCH AND COMMUNICATION IN SCIENCE EDUCATION

Kathryn J. Beam
Joyce Swartney
Francis Siemankowski
Darrell D. Young
Buffalo State University College
Buffalo, New York

and

Rodney Doran
State University of New York
Buffalo, New York

Researchers in science education have amassed extensive information in the last sixty years. The rate of production is ever increasing. We are creating our own "knowledge explosion." Numerous writers have pointed out that the mass of research has yet to produce many clearcut guidelines or principles. One reason espoused for this failure is the lack of a theory or an underlying model for our investigations. Other suggested reasons have included poor definitions, small samples, Hawthorne Effect, and the fact that humans do not behave as regularly as electrons do. The point we would like to address presently is the lack of any underlying model on which to conduct science education research.

Research in science education is accomplished by people at colleges, universities, R & D centers, schools, federal (e.g. NAEP) and private groups as well as by some of the science curriculum projects. Research related to science education is conducted by people in many other disciplines such as math education, psychology, sociology and anthropology.

The preparation of a model from which research ideas could be gleaned as well as on which new ideas could be grafted would be of immense practical and theoretical significance. The model could be used as a framework on which the inter-relationship of some studies may become more apparent. Directions of little research potential could thus be eliminated from future concern and directions of potentially great significance could be illuminated.

Communication of research ideas and products to those who can use them completes the research picture. A one-way communication model with some provision for feedback may extend the usefulness of research. This requires the identification of recipients and means of communication appropriate to them. Practical limitations such as time, money, research sophistication, etc. must be considered. The process of building the communication model suggests ways of making present systems more productive and uncovers needs not presently being met.

Present means of research communication, i.e., journals, ERIC, books, readings, reviews, curriculum projects, career development sessions, etc. will be surveyed. Potential recipient types will be specified. A model matching the research, recipient types, needs and modes will be built. Practical limitations will also be considered.

The communication model would promote professional research and subsequent implementation of results.

NARST members and the Executive Board have requested members of NARST to submit suggestions for increasing the effectiveness of the organization and its meetings. Models of Research in Science Education and Communication of the Research are necessary in order to promote the effectiveness of NARST meetings.

Modes of meeting communication and involvement will be investigated and related to the needs of the meeting participants. Investigations will be made into the efficacy of workshops, paper presentations, symposia, pre-preparation sessions, interaction sessions, proposed research presentations, etc. Criteria for meeting participation, advisory capacities of NARST, the mission of NARST, etc. will also be considered.

Specific suggestions for alternative methods of presenting research and research ideas will be presented by the authors. The suggestions would reflect the Research and Communication Models to be developed above.

Session IVb - Panel Discussion, Hilton 3

"Science Education Research in Other Countries"

Chairman: J. David Lockard, University of Maryland, College Park, Maryland

CONCURRENT SESSION V

Session Va - Symposium III, Statler 1

"Visually Perceived Nonverbal Behaviors of Teachers and Their Relationship to Student Affective Response"

Chairman: Thomas P. Evans, Oregon State University, Corvallis, Oregon

Participants: Joseph R. Kelly, University of Virginia, Charlottesville, Virginia

Anne Raymond, Old Dominion University, Norfolk, Virginia

Paul Eggen, University of Northern Florida, Madison, Florida

VISUALLY PERCEIVED NONVERBAL BEHAVIORS OF TEACHERS AND AND THEIR RELATIONSHIP TO STUDENT AFFECTIVE RESPONSE

Joseph R. Kelly
University of Virginia
Charlottesville, Virginia

Anne Raymond
Old Dominion University
Norfolk, Virginia

Paul Eggen
University of Northern Florida
Madison, Florida

The proposed symposium will consist of three papers which report findings which relate to science teaching and the training of science teachers. Questions to which these investigations relate include the following:

1. Do science teachers display nonverbal behaviors which relate significantly to the affective responses of their students to them?

2. Do students in science classes display nonverbal behaviors which relate significantly to their affective response to the class and the teacher?

3. Do pre-service science teachers who have received training in the use of nonverbal communication display significantly more use of nonverbal communication than untrained teachers?

Investigation A was a study of the visually perceived nonverbal behaviors of thirty teachers, only some of whom were science teachers. Nevertheless, certain considerations in the theory of nonverbal communication suggest that science teachers do not differ significantly from other teachers in their patterns of nonverbal behavior (e.g., nonverbal behavior is learned and culturally-based). Thus, it is reasonable to assume that the findings of this study apply to science teachers as well as other teachers. The findings indicate that certain nonverbal behaviors are strongly related to the induction of affective responses; that boys and girls differ in their responses to teachers' nonverbal behaviors; and that the teacher behaviors which relate most closely to student affective responses tend not to be consciously perceived by the students.

Investigation B was a study of the relationship between student nonverbal behavior as it relates to the students' affective response to their science class and teacher. The findings indicate six nonverbal behaviors which related strongly to positive affective responses, and seven behaviors which related strongly to negative affective responses. The implications of this study relate to the utilization of visual feedback by teachers as a way of assessing the feeling state of students in science classes.

The findings of Investigation C relate to those of Investigation A. The indication is that teachers can be trained to modify their nonverbal behavior in ways that foster more positive affective responses on the part of the teachers' students. Thus, the behaviors determined to relate to positive student affectivity in Investigation A may be "teachable" to the extent that they relate to the design of Investigation C.

Taken together, these three studies suggest some very exciting possibilities for the further study of nonverbal communication in science classrooms and have implications for the screening and training of prospective science teachers.

Session Vb - Discussion Paper, Statler 2

Chairman: Paul E. Bell, Pennsylvania State University, University Park, Penn.

1. "Limitations of Research in Science Teacher Questioning Behavior." Paul C. Beisenherz, Louisiana State University, New Orleans, Louisiana and Jerry L. Tucker, Boise State College, Boise, Idaho.

LIMITATIONS OF RESEARCH IN SCIENCE TEACHER QUESTIONING BEHAVIOR

Paul C. Beisenherz
Louisiana State University
New Orleans, Louisiana

and

Jerry L. Tucker
Boise State College
Boise, Idaho

Objectives: The purpose of this paper is to identify major limitations of past research related to teacher questioning behavior and to provide direction for future research in this area.

Methods: Based on the review of the literature and research on teacher questioning behavior conducted by the authors, the following limitations and problem areas are identified and discussed: importance of teacher variables on questioning behavior--age, science background, and number of years of teaching experience; control of subject content; sampling of teacher questioning behavior; use of syntax and context in the categorization of questions; dimensionality of category systems utilized; use of model instructional strategies; determination of coder reliability; establishment of protocols for categorizing questions; and generalizing from past research on questioning. Each of these problem areas is discussed briefly with emphasis on implications and recommendations for future research efforts.

Significance: One of the challenges to the educational researcher is to provide research that is meaningful for classroom teachers and administrators. Implied from the above review is that future research must evolve that is based on the types of questions teachers should ask. If such prescriptive strategies are to be developed, it would appear that emphasis should be placed on individual teachers and the effectiveness of their questioning strategies on their students in the teaching of particular concepts. Using this strategy, three directions for future investigation are identified and discussed.

Session Vc - Teacher Characteristics, Hilton 1

Chairman: Richard McLeod, Michigan State University, East Lansing, Michigan

1. "An Analysis of Teacher-Self-Assessment and Correlated Student Perception of the Instructional Behavior of Middle School Science Teachers." Sidney P. Smith, Georgia State University, Atlanta, Georgia.
2. "A Study of Classroom Behavior Change Following Teacher Involvement In a Summer Teacher Retraining Program." Susan D. Spradlin, The University of Texas at Austin, Austin, Texas.
3. "An Investigation of the Effects of ISCS Level One on Selected Affective Variables of Students." Lamonte Lauridsen, Baker University, Baldwin City, Kansas and W. S. LaShier, Jr., The University of Kansas, Lawrence, Kansas.

AN ANALYSIS OF TEACHER SELF-ASSESSMENT AND CORRELATED STUDENT PERCEPTION OF THE INSTRUCTIONAL BEHAVIOR OF MIDDLE SCHOOL SCIENCE TEACHERS

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Atlanta, Georgia

Objectives: During the past decade much emphasis and financial support has been forthcoming for various teacher improvement projects, but little research has been conducted to evaluate the effects of these projects with reference to participant change after participating in one or several of these projects.

The problems of this study were: (1) to investigate teachers' perception change identified by the Science Classroom Activity Checklist: Teacher, (2) to investigate teachers' performance change in the classroom identified by the Science Classroom Activity Checklist: Students, and (3) correlate teachers' perceptual change with student reported observations of change. The following hypotheses are posed for analysis and interpretation of the data. $H_{(1)}$: project teachers will not have changed their views significantly about the types of science classroom activities which would be used for science instruction, $H_{(2)}$: project teachers will not have changed their classroom activities which should be used for science instruction, and $H_{(3)}$: there will be no significant relationships between teachers perceptual change and student reported observations of teacher change used in science instruction.

Methods: The teacher sample for this study was twenty-six (26) middle school science teachers representing six (6) county and city school systems in Middle Georgia who participated in a Cooperative College-School Science Project and 208 science students (104 science students taught by project teachers and 104 science students taught by non-project teachers).

To evaluate the nature of the science classroom activities which these teachers purported to use in their instructional mode, the Science Classroom Activities Checklist (Teacher's Perception) was utilized, which was developed by R. L. Sagness. Also, a similar instrument, the Science Classroom Activities Checklist (Students' Perception), developed by the same individual, was utilized to gather data relative to students views in relation to science classroom activities as they perceived them. Both instruments were composed of 60 items with seven subscales. These subscales were (1) Student Classroom Participation, (2) Role of the Teacher in the Classroom, (3) Use of Textbook and Reference Materials, (4) Design and Use of Tests, (5) Laboratory Preparation, (6) Type of Laboratory Activities, and (7) Laboratory Follow-Up Activities. Pre-test and Post-test KR (20) reliabilities for the teacher samples were 0.88 and 0.73.

Results: Hypothesis one was rejected at the 0.05 level of confidence. Teachers showed a significant change in their perception of science instruction for the total sixty item checklist and six of the seven subscales indicated positive mean gains. Hypothesis two was rejected at the 0.05 level of confidence. One hundred and four science students of the teacher sample reported significant difference in teacher performance in science instruction and classroom activities. Hypothesis three was also rejected at the 0.05 level of confidence. Teachers and students of these teachers showed significant positive agreement with regard to science classroom activities.

Significance: It can be concluded that a change in teacher perception and behavior can be an outcome of an instructional project. It is also evident that this change in behavior can be implemented in the classroom and students can detect and evaluate this behavioral change.

A STUDY OF CLASSROOM BEHAVIOR CHANGE FOLLOWING TEACHER INVOLVEMENT IN A SUMMER TEACHER RETRAINING PROGRAM

Susan D. Spradlin
The University of Texas
Austin, Texas

Objectives: The measure of a teacher's effectiveness can best be found in his classroom as he works with students. The way in which he sees himself and his students in his role as a teacher as well as his knowledge and appreciation of his subject should influence his classroom behavior.

The purpose of this study was to determine whether increased subject matter knowledge and exposure to new teaching strategies in a special Institute Program would affect any change in the classroom behavior of an inservice teacher.

Methods: The sample used for this study included 50 science teachers who participated in a Summer Institute Program for Science Teachers at The University of Texas at Austin in 1971 and their 1240 secondary school students. The research design is proposed by Campbell and Stanley as the "one group, pre-test, post-test design." Data collected were treated as separate trials and t-tests were used to determine significant differences.

Data Sources: Prior to the close of the 1970-71 school year, one class for each participant was given the Science Classroom Activity Checklist (SCAC)* and a Student Semantic Differential (SSD). Pre-institute measures taken for the teachers included a Teacher Semantic Differential (TSD), a Teacher Concern Statement (TCS)**, NSTA's Annual Self-Inventory for Science Teachers (ASIST) and content tests for Earth Science, Physical Science and Biological Science.

At the close of the 9 week institute the participants complted the appropriate content tests, TCS and a TSD. Following the next teaching year, all measures were repeated.

Results: Among the null hypotheses statistically tested were the following:

1. There is no difference in the classroom activities of teachers before and after institute participation. (rejected)
2. There is no difference in the attitudes of teachers' students toward the world of science, science class, science teacher, science laboratory and school before and after institute participation. (accepted)
3. There is no difference in the teachers' content mastery before and after institute participation. (rejected)

4. There is no difference in teachers' self-evaluation as professionals before and after institute participation. (rejected)
5. There is no difference in the maturity of teachers' concerns about teaching before and after institute participation. (rejected)
6. There is no difference in teachers' attitudes toward their teaching job, the field of science, their school and teaching situations before and after institute participation. (accepted)

For all hypotheses rejected the difference between means was significant at the .05 level in a positive direction.

Significance: The results of this study would indicate that participation in this Summer Institute Program worked to improve the teachers' classroom behavior patterns, perception of self as professional persons, their level of teaching concerns to more student centered ones, and increased their content knowledge. Within a one year period there seems to have been no change in student attitudes. Teacher attitudes altered little except for a strong feeling that the institute experience was valuable and a strengthened belief in the importance of science for their students. While student attitudes showed no significant change there were indications of a positive trend that would possibly become more positive as the teachers became more secure in their new activities.

This study could serve as a model for evaluating and comparing teacher retraining programs of all types: Summer Institutes, Academic Year Programs, Workshops, Co-operatives, and others. It could aid in determining the degree of change in a teacher's classroom behavior that can be predicted following a specific increase in knowledge and change in self perception and evaluation.

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* A modified form of Kochendorfer's Biology Classroom Activity Checklist.

** Teacher Concern Statement developed by Dr. Frances Fuller, Research and Development Center, The University of Texas at Austin.

AN INVESTIGATION OF THE EFFECTS OF ISCS LEVEL ONE ON SELECTED AFFECTIVE VARIABLES OF STUDENTS

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Baker University
Baldwin City, Kansas

and

W. S. LaShier, Jr.
University of Kansas
Lawrence, Kansas

Objectives & Methods: A pretest-posttest nonequivalent control group design was employed to compare the effectiveness of ISCS Level One with non-ISCS seventh grade science classes in 1) fostering positive growth in the scientific attitudes associated with the nature of scientific laws, the limitations of science, and the desirability of science as a vocation; 2) enhancing the self-reliance level of seventh grade students; 3) elevating the ranking seventh grade students give to science when they rank five classroom subjects in order of their preference.

Furthermore, posttest data were collected to detect any differences in the perceptions students in the two types of classrooms had of eight components of their classroom environments. The classroom variables measured were associated with teacher warmth, teacher demand, teacher use of intrinsic motivation, the role of the teacher in the classroom, student classroom participation, use of the textbook, design and use of tests, and the nature of laboratory activities.

Data Sources: Responses were collected from more than 650 students who were in the classes of 15 ISCS Level One teachers who had participated in a NSF-CCSS Summer Institute held during the summer of 1971 at The University of Kansas. The classes of eight non-ISCS teachers, each of whom taught in a school district represented by the 15 ISCS teachers, provided more than 200 non-ISCS respondents.

Results: Discriminant analyses were performed in testing six hypotheses. Analysis of the pretest and posttest data collected with the instruments designed to measure scientific attitudes, self-reliance, and classroom subject preference led to the following conclusions: 1) the ISCS group experienced a significant positive increase in the attitude associated with the nature of scientific laws, while the non-ISCS group did not undergo as large a positive change in this attitude; 2) the non-ISCS group experienced a significant negative change in the attitude associated with the desirability of science as a vocation, and the ISCS group experienced a negative change in this attitude which was almost as great; 3) both groups experienced a slight, but not significant, increase in the attitude associated with the limitations of science; 4) both groups ranked science lower, but not significantly, in the preferential ranking of classroom subjects on the posttest than on the pretest; 5) both groups experienced slight, but insignificant, increases in self-reliance.

Discriminant analysis of the posttest data gathered with the instruments designed to measure three teacher traits and of the posttest data gathered with the instruments designed to measure the nature of five classroom activities revealed that the level of student participation in the ISCS classrooms was much greater than in the non-ISCS classrooms, and that the ISCS students saw their teachers as being much warmer. These findings suggest that the level of participation in the ISCS classrooms may have allowed the students to view their teachers from a different perspective, thereby enabling them to see their teachers as warmer people. Furthermore, the higher level of student participation may have contributed to the significant positive increase in the attitude associated with the nature of scientific laws which was experienced by the ISCS students.

Session Vd - Instruction, Hilton 3

Chairman: Mary Budd Rowe, University of Florida, Gainesville, Florida

1. "An Invitation To Inquiry." Gary C. Bates, Harvard Graduate School of Education, Cambridge, Massachusetts.
2. "The Annotation of Articles On Biochemistry From *Scientific American* For High School Students." John A. Knapp, II, State University College, Oswego, New York.
3. "An Analysis of the Relationship of Individualized Instruction, Self-Image of Achievement, and Academic Achievement in High School Biology." Donald W. Humphreys, Indiana University, Bloomington, Indiana.

AN INVITATION TO INQUIRY

Gary C. Bates
Harvard Graduate School of Education
Cambridge, Massachusetts

Objectives: With the availability of low cost videotape recording equipment the analysis of "real" classroom and teaching situations has become an increasingly important component of teacher training. Many instructors have, no doubt, been intrigued by the possibility of capturing bits of classroom interaction for use in illustrating particular teaching concepts or for stimulating discussion. Since these unique events occur spontaneously in the very organic atmosphere of the classroom, they cannot be convincingly staged nor precisely timed. It is necessary to record a vast quantity of experience and then select a few sequences which appear to be particularly rich. Because this process is very expensive in both time and money, it is essential that a systematic effort be made to record useful events in a format which allows duplication and circulation to a larger audience.

The Classroom Vignettes pilot film project is an initial step in establishing such a resource. This new teaching aid is a collection of four three to eight minute films of spontaneous small group interactions which were selected from over 10,000 feet of film shot "live" in three science classrooms in the western and eastern United States. These films and auxiliary materials can be used to provide a common experience for introducing students to the observation and interpretation of classroom behavior. Initial trials have demonstrated that observers "see" very different things when viewing the same film and that experienced teachers are more detailed observers and skillful interpreters. Each vignette is short enough to be viewed several times to check divergent observations and to test interpretations. Viewers can also be made aware of the underlying assumptions which influence both their interpretations and observations. The observational, interpretive, and communication skills which students gain from these exercises provide a background for subsequent classroom visitations which are frequently a part of teacher training programs.

Methods: There is a great need to experiment with these materials in a variety of settings and for varied purposes. To this end, interested NARST members are invited to participate in a research study to evaluate and expand the use of these films and auxiliary materials. Feedback from participating institutions will provide valuable information on how to best introduce and utilize the existing films and will suggest new vignettes which would be worth capturing and distributing.

Results: During the fall of 1972 preliminary trials of these materials are being conducted in several schools. The results of these studies will be reported at the March 1973 NARST meeting.

One Hour Workshop: NARST members interested in participating in the research phase of the Classroom Vignettes pilot film project will have an opportunity to view the films and materials, discuss possible uses of the materials, and meet with staff personnel coordinating the project.

THE ANNOTATION OF ARTICLES ON BIOCHEMISTRY FROM SCIENTIFIC AMERICAN FOR HIGH SCHOOL STUDENTS

John A. Knapp II
State University College
Oswego, New York

Objectives: The author of nearly every high school biology textbook suggests, directly or implicitly, that certain articles from Scientific American are useful in achieving certain goals with science students. However, few classes or individual students actually read and use this journal because they consider it to be too technical, or too difficult.

In an attempt to make articles from Scientific American more understandable and readable for high school students, the investigator and a biochemist selected four articles[1] on biochemistry and prepared a set of annotations to accompany the articles. This annotation was designed to define or illustrate difficult words, concepts, or techniques that appeared in the articles. The original articles were pasted on larger sheets of paper and the annotation was typed into the margins.

The purposes of this study were to (1) prepare four annotated articles on biochemistry and (2) determine their effects upon student understanding and opinion.

Methods/Data Source: Data were obtained by testing 603 beginning chemistry, advanced chemistry, and advanced science students from 30 classes in 11 high schools in southwestern Michigan. The twelve-item, multiple-choice tests that were used were constructed by the investigator and the biochemist, and designed to measure student understanding of the articles selected for this study, but excluding the annotation.

On the first day of a three-day experimental period the students each received one annotated article and another, different, article that did not have annotation. The students were instructed to read these articles. On the third day of the experimental period the students were administered appropriate tests to measure their understanding of the articles and a questionnaire designed to elicit student opinion. Also, the teachers partitioned their students into ability groups for the purpose of additional comparisons.

Results: From the responses to the tests and questionnaire the investigator made several comparisons between the readers of the annotated and nonannotated articles. The most notable results were the following:

1. Significant differences (.05) were not detected between the test scores of the readers of annotated articles and those of readers of the nonannotated articles. Hence, within the confines of this experiment, the presence of an annotation did not lead to greater understanding of the original articles.

2. At the conclusion of the study, the students reported that they preferred reading annotated articles to nonannotated ones by a margin of more than four-to-one. Hence, some feature, or features, made the annotated articles more appealing to the students. Attempts to obtain reasons for this preference were inconclusive. In lieu of other explanations the investigator suggests that the annotations, whether used to any great extent or not, made the articles they accompanied appear less threatening than the original articles.

Other features of this paper include: (1) a discussion of possible shortcomings of the study, (2) implications for future research on annotating journal articles, and (3) a survey of the use of Scientific American by the 603 students who participated in this study.

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1. The four articles selected from Scientific American were:

R. B. Merrifield, "The Automatic Synthesis of Proteins." S. A., CCXVIII (March 1968), 56-74.

Philip H. Abelson, "Paleobiochemistry." S. A., CCXCV (July 1956), 83-94.

Marshall W. Nirenberg, "The Genetic Code: II." S.A., CCVII (March 1963), 80-94.

John Cairns, "The Bacterial Chromosome." S. A., CCXIV (January 1966), 36-44.

THE EFFECTS OF TEACHER-SELECTED AND SELF-SELECTED ACTIVITIES ON SELF-IMAGE OF ACHIEVEMENT AND ACHIEVEMENT OF HIGH SCHOOL BIOLOGY STUDENTS

Donald W. Humphreys
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Bloomington, Indiana

Objectives: Learning concepts through student experiences in a variety of related science activities is a viable goal for any science course. The primary objective of the investigation was to determine if concepts are learned better when the students are provided with a science activity by their teacher or when they select or develop the learning experience themselves.

The learning technique for the study was developed from the mastery learning model of Carroll[1] who proposes that when using self-paced learning, if given enough time, virtually all students should be able to attain concept competency. In Carroll's model, a student's self-image of success is a suggested outcome for successful subject matter mastery.

A second objective of the study was to determine the relationship between time needed to develop concept competency and the self-image of academic success of the student. The third objective of the study was observation and interpretation of interaction between the type of learning environment provided for the student, and the self-image of academic success.

Methods: The experiment was conducted for a period of 140 school days in two high school biology classes from the same population. Science concepts for the course were those developed and sequenced by BSCS (Green Version). Component parts of the concept were often presented to the student in the form of a problem. Each student in one group was required to complete a variety of learning experiences developed by the teacher which would lead to the solution of the problem. In the second group, each student was allowed to develop his own learning experience which led toward the solution of the same problem. After conducting a series of related learning experiences, students were tested for concept understanding. Students in the teacher-selected experience group with inadequate concept competency were required to complete additional teacher-selected experiences until they could satisfactorily pass the concept test, while the students in the self-selected experience group selected or developed new experiences. Progression into a new set of learning experiences was allowed only after students had satisfactorily passed the concept test.

Self-image of academic achievement was measured several times during the study by means of a Q sort composed of 50 cards each containing a positive or negative adjective. The sequence of the weighted adjectives determined the student self-image of academic achievement score. Academic achievement was measured by (1) the number of concepts mastered, (2) the BSCS Quarterly Examination, and (3) the BSCS Comprehensive Final Examination.

Results: When the study was concluded, the class which was provided with teacher-selected learning experiences completed more learning experiences and consequently indicated a significantly higher achievement score mean than the class which developed their own learning experiences. Achievement score means did not differ significantly between the two classes, however, when only the concepts experienced by all students were tested. The teacher-selected experiences student group had a more stable image of academic achievement and required a significantly shorter period of time to develop concept competency. The student-selected experience students' self-image of achievement score means became significantly lower than those of the teacher-selected experience students after 40 days of classroom activity although there was not significant difference between the students before and after the study.

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[1] Carroll, John B. "A Model of School Learning," Teachers College Record, 64, (1963), 723-33.

CONCURRENT SESSION VI

Session VIa - "An Hour With" Session, Statler 1

Chairman: Joseph Novak, Cornell University, Ithaca, New York

"An Hour With Milton O. Pella About Concept Learning In Science"

Milton O. Pella
School of Education
University of Wisconsin
Madison, Wisconsin

Session VIb - Instructional Procedures, Statler 2

Chairman: Pauline Gratz, Duke University, Durham, North Carolina

1. "The Relationships Between Two Methods of Teaching College Biology and Achievement and Attitude." Judson M. Vander Wal, Grand Rapids Junior College, Grand Rapids, Michigan.
2. "A Comparison of the Relative Effectiveness of Written Scripts and Audio Tapes In Teaching College Biology." Leonard Simons, Susquehanna University, Selinsgrove, Pennsylvania.
3. "An Investigation of the Effectiveness of Visuals Differing in Degree of Stimulus Explicitness on Learning for Individuals Differing in Entering Behavior." Thomas C. Arnold, State College Area High School, State College, Pennsylvania.

THE RELATIONSHIPS BETWEEN TWO METHODS OF TEACHING COLLEGE BIOLOGY AND ACHIEVEMENT AND ATTITUDE

Judson M. Vander Wal
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Grand Rapids, Michigan

Objectives: This study investigated two methods of teaching biology at the college level for non-science majors. It compared a traditional lecture-laboratory method, used at Grand Rapids Junior College in Grand Rapids, Michigan, with an audio-tutorial approach employed at Western Michigan University in Kalamazoo, Michigan. The students were enrolled in these courses during the 1970-71 academic year.

The primary problem was to investigate the relationships between these two methods of presenting biological information and students' attitudes toward biology and their terminal achievement. A secondary problem involved the comparison of interrelationships among a number of student variables. Many of the variables compared also served as criteria upon which a match-pairing techniques was based.

Methods: There were 259 students who participated from Grand Rapids Junior College and 163 students from Western Michigan University. Since students from two different colleges were used, a match-pairing technique was employed to control for as many variables as possible. A total of 131 matched pairs resulted.

Four instruments were administered as pre- and post-tests. Two student informational questionnaires were employed, one at the beginning of the course and the second at the end. The attitude scale by Silance and Remmers - Attitude Toward Any School Subject - was used to measure the students' attitudes toward their respective biology courses, and the Cooperative Science Test - Biology, Form B, by Educational Testing Services was used to determine achievement levels.

The "t" test was used to determine what differences might exist between the mean scores for achievement and attitude for the following comparisons:

(1) differences between the pre- and post-tests from each college;
(2) differences between the pre-tests from both schools;
(3) post-test differences for both colleges.

Numberous comparisons of the students exposed to the two methods of teaching biology were made concerning:

(1) final grade distributions in relation to sex and year in college;
(2) relationships involving the number of credit hours carried;
(3) relationships involving the number of hours of employment;
(4) relationships involving high school class size distributions;
(5) relationships involving high school grade-point average distributions;

(6) the relationship of sex to numerous variables and course background percentages.

Results: The following were the results of the "t" tests:

(1) Significant differences in achievement were found for both methods of teaching, based on differences between pre- and post-test mean scores from each college.

(2) Significant differences were not found between the mean scores on the pre-tests of the students in the colleges.

(3) Significant differences were not found between the mean scores on the post-tests of the students in the colleges.

(4) Significant differences were not found between the mean scores on the pre- and post-tests of attitudes for the students exposed to the audio-tutorial approach.

(5) There was a negative significant difference between the mean scores on the pre- and post-tests of attitudes for the students in the traditionally-taught class.

(6) Significant differences were not found between the mean scores obtained by the two groups of students on the pre-test for attitudes for the two teaching methods.

(7) Significant differences were not found between the mean scores obtained by the two groups of students on the post-test for attitudes.

A COMPARISON OF THE RELATIVE EFFECTIVENESS OF WRITTEN SCRIPTS AND AUDIO TAPES IN TEACHING COLLEGE BIOLOGY

Leonard Simons
Susquehanna University
Selinsgrove, Pennsylvania

Objectives: The major purpose of this investigation was to compare the relative effectiveness of written scripts and audio tapes for teaching biological concepts.

Four adjunctive objectives were also examined:

1. The ability of students to effectively read the subject matter presented in the experiment.
2. The attitude of students with respect to:
   a. written script instruction
   b. audio tape instruction
   c. the subject matter presented
   d. biology and science in general
   e. the general biology course as it is normally taught
3. The time involved in doing assignments when using each treatment.
4. The relationship of scholastic ability to achievement using the two treatments.

Methods: The experiment was conducted during the first six weeks of the Fall semester of 1971. The study involved 64 students in two experimental groups, and 65 students in controls, selected from approximately 900 students enrolled in the general biology course at Syracuse University.

The experimental groups were given two treatments - scripts and tapes, and two units of biological subject matter - genetics and developmental biology. One experimental group was given audio tapes, and the other was given written scripts as treatments for the first study unit. The treatments were reversed between groups for the second unit of study.

Data Sources: Pre- and post-subject matter examinations prepared by the investigator were given for each unit. Attitude scales were prepared by the investigator utilizing the Likert (1932) format, and administered before the experiment began, at the conclusion of each experimental unit, and at the conclusion of the semester. A Cloze screening reading test was administered, SAT Verbal and Math scores were obtained, and time spent in lab for each assignment was recorded.

Results: A significant ($p < 0.05$) difference in achievement in favor of script instruction was found for the developmental biology unit. No significant differences in achievement were observed between tape and script groups for the genetics unit.

Significantly less time was needed to complete assignments when using written scripts than when using audio tapes for both groups and both units in the study.

Attitudes toward the treatments differed significantly between the two groups, with favorability given to the treatment presented first, regardless of achievement or expediency in time when using the treatment. Attitudes toward biology, science and the subject matter utilized in the study were positive for both groups with no significant differences between them. The groups both felt the general course, with its multimethod approach was the best option given for learning biology.

Evidence collected in the study indicated that scholastic aptitude is directly related to achievement, and regardless of treatment given, people with high aptitude do well.

Significance: The results of this investigation suggest that the addition of written scripts to a course utilizing a multi-method teaching approach, as does the general biology course at Syracuse University, would positively supplement this type of format. Use of scripts in addition to tapes would reduce the time spent on subject areas and increase the possible number of topics or the depth in which a given unit may be examined.

AN INVESTIGATION OF THE EFFECTIVENESS OF VISUALS DIFFERING IN DEGREE OF STIMULUS EXPLICITNESS ON LEARNING FOR INDIVIDUALS DIFFERING IN ENTERING BEHAVIOR

Thomas C. Arnold
State College Area High School
State College, Pennsylvania

Objectives: The purpose of this study was to investigate the relative effectiveness of specific media attributes (increase in realistic detail) on S's performance on criterion tests measuring different levels of understanding. This study was designed to gather data to ascertain which of two levels of stimulus explicitness in visuals facilitated S's achievement most effectively on criterion tests of knowledge, comprehension, and total understanding for students possessing two different levels of entering behavior.

Specifically, the study attempted to determine whether there were significant differences in S's achievement on the criterion tests due to: (a) varying levels of stimulus explicitness in visualized instruction; (b) entering behavior; and (c) a particular combination of entering behavior with a particular level of stimulus explicitness.

Methods: The materials for this investigation consisted of two sets of instructional programs designed in textbook format. The printed subject matter transmitted via these instructional packages was held constant with each package consisting of 37 pages. Each page contained a 2-1/2 inch by 3-1/2 inch illustration of the human heart that was designed to complement the printed content material on that page.

One hundred and seventy-one college Ss were used as subjects. Ss were assigned to one of three entering behavior groups as a result of their performance on a pretest employed for this purpose. Members of each entering behavior group were then randomly assigned to one of two treatment groups. These treatment groups received identifical written presentations; however, each of the two groups received their own respective type of visual illustration containing one of two degrees of stimulus explicitness. Detailed shaded drawings and simple line drawings of the human heart were employed in the instructional packages with the former being defined as possessing a high level of stimulus explicitness and the latter as possessing a low level of stimulus explicitness.

Data Sources: Each S received a pretest before receiving his respective treatment. In addition, each S also received a 44-item criterion test which consisted of two subtests, each designed to measure a specific level of cognitive ability. Achievement scores on the two criterial measures were the dependent variables and the degree of stimulus explicitness in the visualized treatments the independent variable.

V.

A two factor analysis of variance was the statistical model used to analyze the data obtained in this study. Differences were considered significant at the 0.05 level. The two-way analysis of variance model was also used to investigate the interaction effect between entering behavior and instructional treatment.

Results: The results of an analysis of the data obtained in this study indicate that: (a) there was a significant relationship between entering behavior and achievement on the post-criterion measures; (b) insignificant differences existed between the level of stimulus explicitness and achievement on the post-criterion tests; and (c) insignificant differences existed between entering behavior and instructional treatment.

Significance: This study is considered significant because of the new trends in science education utilizing individualized instruction techniques complemented via various types of instructional media (visual). Of particular concern to this investigation was the "Theory of Stimulation" proposed by Salomon which suggested the existence of a relationship between entering behavior and instructional explicitness on S's achievement of specific learning objectives. This theory implies that achievement on an instructional task will be dependent on an individual's entering behavior and the explicitness of the instruction received.

Within the limitations under which this investigation was conducted, the following implication may be derived: Ss possessing high entering behaviors achieve highest on criterion tests (and Ss with low entering behaviors achieve lowest on criterion tests), regardless of the type of visualized presentation they receive. Consequently, science educators may not need to design and produce different types of visualized materials for Ss possessing differing entering behaviors. These results contest the use of Salomon's Theory of Stimulation as a viable guide for science educators to consider and production of visual aids to be used for instructional purposes.

Session VIc - Teacher Education, Hilton 1

Chairman: Judy Egelston, State University of New York, Geneseo, New York

1. "The Effect of Early Classroom Teaching Experience Upon The Attitudes and Performance Of Science Teacher Candidates." Diane R. Conradson, California State University, San Jose, California.
2. "The Effects Of Learning a Mastery Teaching Strategy On Teacher Attitudes and Effectiveness." James R. Okey, Indiana University, Bloomington, Indiana.
3. "Attitude Change As A Result Of A Short Course On Environmental Quality." James L. Milson, The University of Texas, El Paso, Texas.

THE EFFECT OF EARLY CLASSROOM TEACHING EXPERIENCE UPON THE ATTITUDES AND PERFORMANCE OF SCIENCE TEACHER CANDIDATES

Diane R. Conradson
California State University
San Jose, California

Objectives: This study was designed to allow sophomore and junior science major college students the opportunity to explore teaching as a possible career through actual classroom teaching experience. It was hypothesized that students would receive a sufficiently realistic view of a teacher's role as to be self-screening, with their attitudes toward teaching reinforced by the experience, either positively or negatively.

Methods: About 80 science major or minor students, mainly juniors interested in teaching as a career, volunteered to take an experimental, non-graded course at California State University-San Jose in early classroom experiences in science teaching. The students were paired, based upon 11 items considered significant in matching. One of each pair was randomly selected to be in the experimental group, the other in the control group. Thirty two pairs of students finished the study. An attitude inventory of 57 items covering seven categories of attitudes toward teaching was developed. The attitude inventory was given as a pre- and posttest to both the experimental and control groups at the beginning and end of the semester, four months apart. After taking the pretest, the experimental students were individually placed in the grade level and science area of their choice, with master teachers selected for their excellence in science teaching. The experimental students spent a minimum of three hours per week for 12 weeks in the classroom. They were given an open assignment to spend the time observing first, then tutoring, teaching small groups, developing and teaching one or two complete lectures or labs, and aiding the master teaching by setting up labs, correcting papers, etc., with emphasis on interaction with the pupils. Most of the experimental students met with the investigator several times during the semester to discuss problems and progress. The control group was given no assignment except to take the attitude inventory on the two occasions it was given.

Data Sources: The t test was used to determine the statistical significance of differences in mean scores (if any) of the matched pairs, 0.05 being considered statistically significant. All students were considered together, whatever their grade level or science area choice, because of the small size of the sample. At the end of each of the two semesters the course was offered, students evaluated the course and discussed their attitude toward continuing in a teaching career. They also received a 37-item evaluation by their master teachers, part of which was based on the attitudes covered in the inventory, the rest on specific items suggested by the students. Since the master teachers' evaluations were confidential and were not used in determining grades, most of the teachers were critical without hedging, and the students' strengths and weaknesses were made clear.

Results: The t tests indicated the attitude concerned with grade school science as processes, not only content, was statistically significant at the 0.05 level. The remaining six attitudes all showed differences in the hypothesized direction, but did not attain statistical significance. The total attitude inventory was statistically significant at the 0.05 level. The subjective evaluation consisted of responses to an open-ended questionnaire and cannot readily be evaluated quantitatively, but perhaps gives a better feedback of attitude changes than the inventory. As a result of the classroom experience, all of the experimental students appeared to gain a realistic view of teaching at the grade school level, since almost without exception they commented that teaching was far more work than they had imagined, or took far more time than they had expected. Several students withdrew from the course, stating that it took too much time. Four students decided not to become teachers. About 14 or 15 were still undecided about a teaching career, but felt they knew what was involved. The remainder felt either reinforced in their original plans to become teachers or decided to enter the credential program.

Significance: From the upward trend of the attitude inventory scores and the responses of both the students and master teachers, a course offering early classroom teaching experience apparently does aid in screening students, who are considering a teaching career in science, into and out of teaching careers.

THE EFFECTS OF LEARNING A MASTERY TEACHING STRATEGY ON TEACHER ATTITUDES AND EFFECTIVENESS

James R. Okey
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Bloomington, Indiana

Objectives: The purposes of this investigation were a) to alter teacher's attitudes toward testing, grading, and diagnostic teaching, and b) to teach teachers a systematic plan to follow in order to be more effective. Bloom has hypothesized that most students can master our courses, not just a few, and that it is the task of teachers to make this occur. To accomplish this, Bloom states that both an attitude and a behavior change by teachers is needed. In this investigation both of these were tackled; an attempt was made to alter the attitudes and teaching procedures of teachers and to measure the effect on student achievement.

Methods: Inservice teachers (N = 21) studied a 5-hour, multi-media, self-instructional program called Teaching for Mastery (TFM) designed to teach them to implement Bloom's mastery teaching strategy. Objectives, practice problems, feedback on exercises, self-tests, and answers are given for each of the six sections in the TFM program.

Following instruction in the TFM program, each teacher implemented mastery teaching in either a science or math class. Three different experimental designs were used. The results from a sub-group of five teachers using a Posttest-Only Control Group Design will be reported here. Each of the five teachers split their class using random procedures and for a two week unit taught one group using a mastery teaching strategy and and other group without using it. This means that the teacher gave frequent diagnostic tests to one group and attempted to remedy any errors they had and did not do this with the other group. While the teacher taught one group the other half of the class would go to the library or another classroom. Objectives, classroom exercises, diagnostic test items, remedial materials, and a posttest were provided each teacher. After two weeks each teacher administered the posttest to learners in both groups.

Data Sources: A 22-item test was administered to the 21 teachers before and after studying the TFM program to measure attitudes toward testing, grading, and diagnostic teaching. The posttest administered to the students by the teachers following study of the two week unit had one unit keyed to each objective the teachers were to accomplish. All test papers were graded by the experimenter.

Results: A highly significant difference ($p < .001$) was found between the pre- and posttest attitude measures. The 21 teachers regarded tests, testing, and diagnostic teaching more favorably following study of the

TFM program. Achievement results for students on the 20 objectives favored the mastery group for each of the teachers. The overall probability of obtaining the observed results was significant ($p < .05$).

Significance: The true test of teacher training materials is whether they lead to increased student achievement. In this study, the effect of teachers' studying and using skills designed to promote student achievement was found to do just that. Teachers were able to produce higher achievement when they used the skills than when they did not. To a greater extent, teacher training programs should be based on skills with demonstrated classroom power.

ATTITUDE CHANGE AS A RESULT OF A SHORT COURSE ON ENVIRONMENTAL QUALITY

James L. Milson
The University of Texas
El Paso, Texas

Objectives: The primary purpose of this study was to determine what attitude changes take place in a group of secondary school teachers as a result of participation in a short course on the environmental problems of air pollution, water pollution, noise pollution, population problems and the use of natural resources. A secondary purpose of the study was to determine if the teachers perceived the course structure an effective method for presenting environmental topics.

Methods: During the summer of 1972, a group of 43 secondary school teachers met with 40 specialists in the areas of air pollution, water pollution, noise pollution, population problems and uses of natural resources. Each of these topics was introduced in a panel discussion, the panel consisting of 3 to 5 specialists from governmental agencies, industry and representatives from concerned environmental groups. Each panelist was given 30 minutes to present the viewpoint of his organization. Following these presentations, a discussion session provided an opportunity for the participants and panelists to probe the topic in greater depth. Several times during the course, the specialists and participants planned and became involved in field study tours in order to examine an area problem on a first hand basis.

Data Sources: The evaluation design can be designated as a non-equivalent control group pattern. From a pool of potential participants, 43 were assigned to the experimental group and 45 to the control group. Two questionnaires relating to environmental attitudes and environmental management were administered to both the experimental and control groups. Responses to the items on these instruments were collected as pre- and post-test for individuals in the experimental and control group. The pretest was given to both groups before any activities began. After a period of 15 instructional days, during which the experimental group was involved in the short course activities six hours per day, both groups were administered the post-test. A third instrument relating to the participants' evaluation of the structure of the workshop was administered as a post-test only.

Results: Examination of the resulting data by analysis of variance indicates a statistically significant change in responses occurring for 18 of the 30 items on the questionnaire dealing with environmental attitudes, and for 25 of the 30 items on the questionnaire dealing with environmental management. Responses to the third questionnaire indicate that 90 percent of the participants rated the specialists, format, sequence, length, level of content and physical facilities of the short course at the above average to excellent level

These results suggest that the short course did change the participants' attitudes toward certain aspects of the selected environmental problems. It further suggests that structure of the course was perceived as highly acceptable by the participants.

Significance: Recognizing the limits imposed by the experimental procedure, this study may have implications for science educators who are involved in the design of in-service instruction. If the intensive short course does, in fact, alter attitudes on emotion-charged issues such as environmental problems, then it is possible that attitudes in other areas may be changed in like manner. The teachers' strong response to the structure of the course may suggest the involvement of in-service trainees with consultants from governmental agencies, industry and representatives of citizens groups on an intensive basis.

Session VId - Achievement, Hilton 3

Chairman: John Hassard, Georgia State University, Atlanta, Georgia

1. "The Interpretation of Student Performance On Evaluative Tests." Glen S. Aikenhead, University of Saskatchewan, Saskatoon, Saskatchewan.
2. "A Comparison Of CHEM Study Classes and Traditional Curriculum Classes With Respect To Achievement and Attitudinal Measures." Frances Lawrenz and Arlen R. Gullickson, University of Minnesota, Minneapolis, Minnesota.
3. "The Relation Between Students' College Board Science Scores and Their Mathematics Program." Robert G. Bridgham, Stanford University, Stanford, California.

THE INTERPRETATION OF STUDENT PERFORMANCE ON EVALUATIVE TESTS

Glen S. Aikenhead
University of Saskatchewan
Saskatoon, Saskatchewan

Objectives: The purpose of the study was: (1) to explore the limitations to the use of quantitative data in evaluating a science course, and (2) to investigate another form of information, qualitative data. The investigator evaluated Project Physics in order to compare the roles of quantitative and qualitative data.

Methods: Quantitative compariesons (*t* tests for matched pairs) were made with the test scores of students studying Project Physics and students studying other physics courses. Qualitative data emerged from an item analysis of the same tests. The McNemar chi square statistic yielded a list of items which experienced a statistically significant change in student response between a pretest and posttest. The content of these items represented knowledge which the students tended to acquire during their year of study.

Data Sources: In the 1967-68 nation-wide evaluation of Project Physics, fifty-five teachers were randomly selected from a total population of physics teachers in the United States. These teachers were then randomly assigned to teach Project Physics or the physics course they would have ordinarily taught. An additional group of nineteen teachers, experienced at teaching Project Physics, volunteered to participate in the evaluation project. They taught in various regions of the United States. In this present study there were 921 Project Physics students and 267 non-Project Physics students. These students, selected at random from the total group of students, responded to the pretest and posttest of the Test on Understanding Science (TOUS) or the Science Process Inventory (SPI). The data for this investigation come from the students' responses to the TOUS and SPI.

Results: Quantitative comparisons between Project Physics and non-Project Physics students implied that the Project Physics group achieved significantly greater gain scores than the control group. However, this quantitative information was found to be most ambiguous. By analyzing student response item by item, by comparing both groups of students with respect to their gains in different areas of knowledge, by considering the acquisition of misinformation, one is led to a much fuller understanding of the impact of Project Physics. Not only can one say the Project Physics students achieved more than non-Project Physics students, but one can better understand in what ways (by what knowledge) the groups differed. In four areas specifically: (1) the tactics of science, (2) the values of science, (3) the institutional functions of science, (4) the interaction of science with society, the Project Physics achievement greatly exceeded that of the control group. While quantitative data do play a logical role in determining statistical conclusions for experimental studies, this role might best be limited to a minor one when identifying student achievement for the purpose of course evaluation.

Significance: The increased specificity in the results from qualitative analysis over solely quantitative analysis has direct consequences for formative evaluation. The quality of feedback seems to be enhanced by the inclusion of qualitative information. This type of data increases the clarity in the comparison of student achievement with: (1) a control group, and (2) the stated objectives of the course.

A COMPARISON OF CHEM STUDY CLASSES AND TRADITIONAL CURRICULUM CLASSES WITH RESPECT TO ACHIEVEMENT AND ATTITUDINAL MEASURES

Frances Lawrenz

and

Arlen R. Gullickson
University of Minnesota
Minneapolis, Minnesota

Objectives: Several studies have compared the CHEMS with traditional chemistry curricula. Most conclude that student achievement does not depend upon the type of curriculum used. However, Troxel, 1970, stated that CHEMS results in greater student achievement. That study together with one by Forchtner, 1968, suggests that students may prefer the CHEMS course because of the resulting classroom atmosphere. This study had two functions: (1) to provide additional comparative evidence concerning class achievement and (2) to compare the attitudes and classroom environments of classes using the CHEMS and the Modern Chemistry curricula.

In general, previous studies have had two major shortcomings. (1) The studies were quasi-experimental in nature. (2) Analysis of data was done by using the student rather than the class as the basic statistical unit. That can produce serious nonindependence problems and result in misleading conclusions. This study reduced the potential problems associated with quasi-experiments, and nonindependence problems were eliminated by using class means as the unit for statistical analysis.

Methods: All data were obtained as part of a large NSF evaluation project within which schools, and one chemistry class per school, were randomly selected. A total of 57 of those classes used either the CHEM curriculum or the Modern Chemistry curriculum. Those classes constituted the sample used in the study. As a result, this study was also a quasi-experiment.

To reduce potential selection bias problems, three variables were used as covariates: (1) teacher's knowledge of science processes as measured by the Science Process Inventory (SPI), (2) teacher's attitude toward science as measured by the Science Attitude Inventory (SAI), and (3) the size of the cities within which schools were located.

Each teacher was asked to complete a questionnaire, the SPI, and the SAI. That teacher also administered four instruments, the SPI, a Test of Achievement in Science (TAS), the SAI, and the Learning Environment Inventory (LEI), to students of his selected class. In order to obtain class measures on each of the instruments and at the same time complete the entire testing program in one class period, the class was divided into thirds. One-third took the TAS, one-third took the SPI, and the remaining took both the SAI and the LEI.

On the basis of the teacher's response to a question regarding the chemistry class's ability, the classes for each curriculum were divided into three categories: high ability, average ability, and diversified. That variable was used with the curriculum variable to form a 3 X 2 factorial design.

Results: A MANCOVA program was used to test differences in science knowledge and achievement due to differing curricula. Results of the multivariate test support most previous studies, i.e. SPI and TAS class mean scores for the two curricula were not different ($p > .05$). Also while SPI scores differed across ability levels ($p < .05$), there was no interaction between curriculum and ability.

Also, univariate analysis of covariance tests were run for each of six attitudinal dependent variables. Two of those variables, the LEI subscales of Difficulty and Satisfaction, appeared to be affected by the curriculum ($p < .05$). CHEMS classes perceive their course of studies as more difficult and less satisfying than do Modern Chemistry classes.

THE RELATION BETWEEN STUDENTS' COLLEGE BOARD SCIENCE SCORES AND THEIR MATHEMATICS PROGRAM

Robert G. Bridgham
Stanford University
Stanford, California

Objectives: In this study an attempt is made to determine if the type of mathematics curriculum -- traditional or modern -- a student encounters in the secondary school affects the student's achievement in the sciences.

Methods: A set of achievement and aptitude variables measured in the seventh and eighth grade, the student's sex, an index of the affluence of the student's community, the number of years the student has studied mathematics, and a characterization of the mathematics text used each year as either "traditiona," "modern," or "mixed," was available for each student in the sample. In addition, for each student there was available a score on at least one of the College Board science achievement tests (in Biology, Chemistry, or Physics). A student's curriculum experience in mathematics was characterized by two variables: Years of Mathematics studied and Proportion Traditional. Proportion Traditional was calculated by assigning the value "0" to a modern text, "1" to a "mixed" text, and "2" to a traditional text, and finding the mean value for all the mathematics texts used by a student in the course of his or her secondary studies in mathematics.

The correlation between the College Board Score in Biology, Chemistry, or Physics and the variable Proportion Traditional was studied as the other variables were "partialled out." First the effects of the input variables -- achievement and aptitude in the seventh and eighth grade, sex, and community affluence -- were removed, and then Years of Mathematics was partialled out. In secondary analyses, the index of community affluence was not included in the data set, and similar analyses were performed.

Sample: The sample included all students in the "Y" population of the National Longitudinal Study of Mathematics Achievement (NLSMA) for whom all the indicated data were available. The total "Y" population included 39,988 students. Of these 548 had taken the CB Biology test, 632 the Chemistry test, and 279 the Physics test. Incomplete data for some of the NLSMA data caused a further reduction of the biology sample to 496, of the chemistry sample to 505, and of the physics sample to 228. Losses due to incomplete data appear to be random.

Results: The zero order correlations between Proportion Traditional and College Board science scores are -.20 in biology, -.24 in chemistry, and -.22 in physics. When all other variables have been removed they fall to -.09 in biology, -.04 in chemistry, and -.09 in physics (all nonsignificant). When all other variables except community affluence are removed, the partial correlations are -.13 in biology ($p \leq .05$, -.15 in chemistry ($p \leq .01$), and -.22 in physics ($p \leq .01$). Since community affluence and *Proportion Traditional* are correlated -.3 to -.4, it is unclear whether choice of curriculum is one source of the effect of community affluence, or whether community affluence acts through other means and the apparent curriculum effect is only an artifact of their association.

Significance: Although the possible curriculum effect noted here is small (between one and four percent of the variance in science achievement) it is consistent with what one might expect. The findings provide some tenuous evidence that the mathematics learned in modern curricula is somewhat more transferable to other areas of thought and action. Even if a more conservative view of the findings is taken, there is no indication that the student who gains a deeper insight into mathematical thought through the new curriculum suffers any disadvantage in the practical use of mathematics in one important domain of application -- the sciences.

GENERAL SESSION II

PRESIDENT'S ADDRESS Wayne Room

"SCIENCE EDUCATION RESEARCH - A GLOBAL VIEW"

J. David Lockard
University of Maryland
College Park, Maryland

CONCURRENT SESSION VII

Session VIIa - "An Hour With" Session, Statler 1

Chairman: Joseph Lipson, University of Illinois, Chicago, Illinois

"An Hour With Leo. Klopfer About New Directions in Science Education Research"

Leo. E. Klopfer
University of Pittsburgh
Pittsburgh, Pennsylvania

Although science education research is currently pursued with vigor and with increasing sophistication, it has little direct effect on what happens in science teaching in classrooms. Something is clearly amiss. I suggest that it is the nature of the science education research itself which is largely at fault. Hence, this research must emphasize certain new directions. One of these is along the lines of more intimate, as well as more holistic, careful studies of science instructional materials and science learning environments. Another important new direction, which we can ill afford to neglect, is a concerted incursion into the affective domain as it relates to learning and teaching science.

Session VIIb - Discussion Paper, Statler 2

Chairman: Lynn Glass, Iowa State University, Ames, Iowa

1. "Relationships Between Teacher Practices and Student Learning Of Inquiry Processes." Richard M. Bingman, Mid-Continent Regional Educational Laboratory, Kansas City, Missouri.

RELATIONSHIPS BETWEEN TEACHER PRACTICES

AND STUDENT LEARNING OF INQUIRY PROCESSES

Richard M. Bingman
Mid-Continent Regional Educational Laboratory
Kansas City, Missouri

Objectives:

1. Identification of similarities and differences between students in the Inquiry Role Approach (IRA) project and students not in the project with regard to measures of: a) attitudes; b) cognitive processes; c) perception of social operations; and d) cognitive operations.

2. Identification of similarities and differences between IRA and non-IRA teachers on measures of classroom practices.

Methods: The method was a post only design comparing IRA to non-IRA classes on several measures. Three tests were used: a) The Views and Preferences of Students (V-P), b) Biology Students Behavior Inventory (BSBI), and c) Explorations in Biology (EIB).

The students in each class were randomly divided into four groups. Group 1 took the Views and Preferences of Students; Group 2 took the Biology Students Behavioral Inventory; Group 3 took the Explorations in Biology, Book A; Group 4 took the Explorations in Biology, Book B.

All tests were administered by Laboratory staff and immediately collected and returned to the Laboratory. The data processing department then scored and processed all the data. Differences between groups were tested for significance by t tests.

Data Sources: Four teachers and 424 students from Shawnee Mission West high School, Kansas, were involved in this testing. Two teachers with a total of ten classes are IRA teachers while the other two teachers are non-IRA teachers and had a total of seven classes. These are 10th grade biology classes which use BSCS Blue Version textbooks. The students are randomly assigned to biology classes and are not tracked.

Results: IRA students scored significantly higher than non-IRA students on measures of: 1) social operations - V.P. - (.05), 2) cognitive operations (.001), 3) cognitive inquiry processes - E1B-3-A (.01), 4) cognitive inquiry processes - E1B-3-B (.001), 5) openness - BSBI (.01), 6) responsibility - BSBI (.001). IRA teachers scored significantly higher than non-IRA teachers on the measure of teacher practices (.05) as measured by the Views and Preferences of Students Test.

There was no significant difference between IRA and non-IRA students on measures of: 1) curiosity - BSBI, and 2) satisfaction - BSBI.

The original questions in the evaluation design are answered in the affirmative. There are significant differences between IRA and non-IRA classes on measures of attitudes and cognitive processes with the exception of curiosity and satisfaction. There are significant differences in students' perceptions of social operations, cognitive operations and teacher practices between IRA and non-IRA classes.

These results suggest that differences in cognitive results and certain attitudes, social operations, cognitive operations and teacher practices have developed simultaneously. How these classes of variables are interrelated is not yet known.

Significance: The emphasis on teaching inquiry aspects of science has been quite obvious since the mid 1950's. The BSCS and McREL jointly developed inquiry objectives for teaching biology in order to clarify what these aspects of inquiry are. This study is a continuation of the investigation into specifying goals for inquiry learning and the teacher practices which are most effective in guiding students to attain these goals. These post-only correlational studies help to identify some teaching practices which may be included in future research to determine those practices which are most effective.

Session VIIc - Learning Theory, Hilton 1

Chairman: Patricia Blosser, The Ohio State University, Columbus, Ohio

1. "A Developmental Study in Assessing Children's Ability To Solve Problems in Science." Robert E. Norton and David P. Butts, The University of Texas at Austin, Austin, Texas.
2. "An Investigation Into The Effects of Generating Hunches Upon Subsequent Search Activities in Problem Solving Situations." John T. Wilson, University of Florida, Gainesville, Florida.
3. "Elementary Science Study (ESS) Materials and Creativity." Piyush Swami, The Ohio State University, Columbus, Ohio.

A DEVELOPMENTAL STUDY IN ASSESSING CHILDREN'S ABILITY TO SOLVE PROBLEMS IN SCIENCE

Robert E. Norton

and

David P. Butts
The University of Texas
Austin, Texas

Objectives: In this study a test (the TAB Science Puzzler) was designed as a measure of problem-solving performance. The five parts or subtasks of the test coincided with the five steps of a selected problem-solving model: (1) Problem Orientation, (2) Problem Identification, (3) Problem Solution, (4) Data Analysis and (5) Problem Verification.

Three questions were considered: (1) Is there a relationship between previous science knowledge and problem-solving performance, (2) Is there a relationship between IQ, age or reading ability and problem-solving performance and (3) Is there a relationship between selected cognitive factors of intelligence and problem-solving performance?

Methods and Data Sources: The 27 fourth, fifth, and sixth grade children in the sample came from ten different schools distributed among the four quadrants of the Austin Independent School District in Austin, Texas. Their mean IQ was 116 and their mean chronological age was 127.2 months.

The TAB Science Puzzler utilized the TAB format to measure both total problem-solving performance and performance on the five test subtasks. Interform reliability on each of the three forms of the TSP was determined to be .61 for form B, .42 for form C, and .80 for form D. Intraform reliabilities between parallel forms of the TSP were .73 for forms B and C, .68 for forms B and D, and .80 for forms C and D.

Children's problem-solving performance scores on the TSP were correlated with their scores on a test of previous knowledge in science, The Science Knowledge Test, which was designed to sample children's knowledge of science principles involved in each form of the TSP, IQ scores, reading achievement scores and selected tests from the Kit of Reference Tests for Cognitive Factors.

Results: Findings indicated that (1) problem-solving performance is related to previous knowledge and (2) although the selected cognitive factors are not related to total problem-solving performance, flexibility and speed of closure and reasoning are related to the problem-solving subtasks Problem Orientation, Problem Solution and Data Analysis. Based on the correlations between problem-solving performance and IQ, age and reading ability, no evidence was found to support a relationship between problem solving and these three factors. Chronological age appears to be related to problem-solving in certain problem areas.

AN INVESTIGATION INTO THE EFFECTS OF GENERATING HUNCHES UPON SUBSEQUENT SEARCH ACTIVITIES IN PROBLEM SOLVING SITUATIONS

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University of Florida
Gainesville, Florida

Objectives: Events that contradict prior experience and knowledge may cue observers to initiate a search for an explanation. As part of the search behavior, observers tentatively identify factors as possible causes for the contradictory event. This behavior will be defined here as generating hunches.

The object of this study was to investigate the effect that generating hunches had on subsequent search activities in problem solving situations. In particular, the following questions were of primary concern:

1. Does hunch generation effect the number of procedures the student tries?

2. Is there a relationship between the generation of hunches and the quality of the solution selected for presented problems?

Methods: Forty-five students, ages nine through eleven, were randomly assigned to three groups. Each group first observed a contradictory stimulus event. Experimental group one then wrote hunches while experimental group two read a set of hunches provided. The control group performed no hunch activity. All three groups then were required to classify a set of procedures as "useful" or "not-useful", relative to the contradictory event. Each pupil was then given the materials and procedures he classified as useful. Following this activity, all pupils completed a second measure consisting of a post-test of the quality of the solution formulated. The over-all time for completing the program was also recorded.

Data Sources: The independent variables in this study were pupil-generated hunches or pupil-read hunches. Two dependent variables were measured: pupil classification of procedures as "useful" or "non-useful" for finding a solution to the experimental question, and the pupil's ability to modify a situation in order to solve a problem similar to the experimental problem. These variables were then computed by counting the "useful" responses and the number of modifications pupils made in order to solve the problem. Interrater agreement when necessary on the reliability of the measures was computed by percent agreement and was approximately .8.

Results: ANOV and Tukey's test of "Honestly Significant Differences" were performed and means and standard deviations computed. The findings of the study supported the notion that generating hunches directly influenced the search behavior initiated by the novel context of the stimulus event as well as the quality of the solution formulated. Subjects who wrote hunches classified significantly fewer procedures as "useful" ($p < .05$), spent significantly ($p < .05$) more time in the search activity, and demonstrated a significantly ($p < .05$) higher quality of solution formulated. No significant differences were found between the group that read hunches and the control group.

Significance: Discovery and problem solving activities place most of the selection of what is learned under the control of the learner. However, in terms of the social value of what learners need to learn, some external control seems necessary. By structuring the stimulus events and arranging the learning conditions so that hunches are generated the teacher can influence the search activity and the quality of the solution formulated.

Although research findings of this type are tentative and require continued exploration, their implications for curriculum design and teacher training in science are of major importance.

ELEMENTARY SCIENCE STUDY (ESS) MATERIALS AND CREATIVITY

Piyush Swami
The Ohio State University
Columbus, Ohio

Objectives: Creativity has evoked considerable interest among educationists in the past two decades. The "Structure of Intellect" proposed by Guilford and the probable weak relationship between creativity and I.Q. have been significant steps forward in understanding the nature of creativity. Implications of these research studies are far-reaching for schools.

The purpose of the study was to assess the effectiveness of Elementary Science Study (ESS) materials for developing creativity in children.

Three hypotheses were formulated to the effect that children who receive ESS instruction will achieve higher scores on Torrance Tests of Creative Thinking (TTCT) Figural and Verbal, and the investigator's made test of Observation and Classification.

Methods and Data Sources: The sample was drawn from two elementary schools representing heterogenous populations. Each had two third grade classrooms, both of which participated in the experiment to reduce effects of lack of random selection of children for the experiment which was not possible.

In the pre- and post-test design, a battery of three tests was used each time. Figural form of TTCT and test of Observation and Classification were administered to all children in four classrooms. Verbal form of TTCT was administered to randomly selected 30 children from the four classrooms. Alternate forms of tests were used in pre- and post-tests.

After the pre-test, two classrooms, one in each building, were selected as experimental and the rest as controls. The ESS units were used in experimental classrooms while instructions went on in the usual manner in control classrooms. All classes were taught by the regular classroom teachers. No information was given to the teachers about the creativity aspects of the study until after the end of the experiment. Teachers were asked to use and assess the effectiveness of ESS units in general. Four ESS units were taught for a period of eight weeks.

The pre- and post-test scores were scored for nine different measures. These were Figural Fluency; Figural Flexibility; Figural Originality; and Figural Elaboration, Verbal Fluency; Verbal Flexibility, and Verbal Originality. The test of Observation and Classification was scored for Fluency and Flexibility.

Results: One way analysis of covariance was performed separately for the nine sub-test scores using pre-test score as covariates. Besides gaining information about F-ratios, 2 X 2 summary tables were set up for pre-test, post-test, and post-test means adjusted according to covariance analysis (compensation for pre-existing pre-test differences). These tables provided important information to decide the effect of school, treatment and interaction of two variables on the significance of results. Seven sub-tests were found significant at .05 level. Six of these revealed treatment and the seventh sub-test revealed the interaction factor between school and treatment as major responsible factor for change.

Two hypotheses were accepted. The third, rejected, hypothesis gave some evidence of significant results. More thorough data should be collected to test the third hypothesis.

Significance: The results are quite conclusive, indicating that ESS materials are useful for promoting creativity in elementary school children.

Session VIId - Student Characteristics, Hilton 3

Chairman: Stanley L. Helgeson, The Ohio State University, Columbus, Ohio

1. "The Relationship Between Concept Attainment and Verbal Predictive Ability For Primary Grade Children." K. Michael Hibbard, Greenwich Public Schools, Greenwich, Connecticut.
2. "Predicting High and Low Success-Group Membership In An A-T Biology Course." Thomas E. McDuffie, St. Joseph's College, Media, Pennsylvania.
3. "Four-Year Follow-Up On Physics Students." Fletcher G. Watson, Harvard University, Cambridge, Massachusetts.

THE RELATIONSHIP BETWEEN CONCEPT ATTAINMENT AND VERBAL PREDICTIVE ABILITY FOR PRIMARY GRADE CHILDREN

K. Michael Hibbard
Greenwich Public Schools
Greenwich, Connecticut

Objectives: This study investigated the relationship between 1) a primary grade child's knowledge of certain science concepts, 2) his verbal predictive ability in those conceptual areas, and 3) his general reading ability.

Methods: The science instruction for six first grade classrooms took the form of 16 audio-tutorial lessons. In sequence the lessons were placed in a carrel in the room at the rate of one each week. Each child was allowed one or more turns.

Testing for concept attainment was done through picture tests with tape recorded instructions which were administered individually in the carrel. Individual interviews were also employed.

A modification of the "cloze procedure" was used to test verbal predictive ability within conceptual areas included in the picture tests and interviews. A set of three short sentences was developed for each concept. A noun or action verb was deleted in each sentence and a ten space blank marked its location. Three choices including the correct word were listed in a column above the blank. The sentence, but not the words in the column, was read to the child who was asked to circle the best of the three choices.

A child's reading score included a class ranking made by the teacher and scores on standardized tests taken at the end of first grade.

Data Sources: All the children in a class were ranked according to their reading ability. This list was divided into thirds. Three children were randomly selected from each third from each class to give a total of 54 children. The following data were collected for these 54 children:

1. picture test scores for science concepts
2. interview scores for the same concepts
3. verbal predictive ability scores for those concepts
4. reading ability score (teacher's ranking and standardized tests)

Results: A brief summary of the results follows:

1. no correlation between the child's science test scores and his reading ability (The poor readers as a group did as well learning the science concepts as any of the other reading ability groups.)

2. slight positive but non-significant correlation between reading ability and verbal predictive ability

3. high positive and significant correlation between science tests and verbal predictive ability -- the more the child knows of the science concepts the better he is in selecting the correct word to fill-in the blank

Significance: Many children experience difficulty in learning to read. As early as the beginning of first grade some are labeled non-readers and the term "non-learners" is often used by their teachers to describe them.

How can these co-called non-readers-non-learners be helped? Given individualized, audio-tutorial instruction in which the child can control the rate, number of repetitions, and the amount of direct hands-on experience, he can successfully master science concepts. The child's newly attained structured knowledge and high motivation can be used as a foundation on which to build more reading-type language experiences. Inventorying semantic probability is one cognitive skill involved in learning to read. This study shows that verbal predictive ability (an instance of inventorying semantic probability) is highly correlated to the child's concept knowledge. Therefore, allowing the non-reader to build structured science concepts and then involving him in language experiences within those concepts areas may be an effective way to develop his reading abilities.

PREDICTING HIGH AND LOW SUCCESS-GROUP MEMBERSHIP IN AN A-T BIOLOGY COURSE

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Objectives: The study examined relationships between personal characteristics and achievement in and attitude toward an audio-tutorial (A-T) biology program. The focal point of the investigation was: Is there a differential profile for: (1) high and low achievers, (2) students with positive and negative attitudes toward the instructional method, and (3) successful and unsuccessful students?

Data Sources: One hundred nineteen (35 males and 84 females) in a year-long A-T Biology program at Elizabethtown College (Pa.) formed the study's population. Eighteen variables were measured using standardized indices--CEEB scores, Nelson Biology Test, Moore's Scientific Attitude Inventory and the Guilford Zimmerman Temperament Survey--plus an attitude questionnaire developed for the study.

Data Analysis and Results: After calculating an internal reliability for the attitude questionnaire of 0.96, analysis proceeded in two stages. First, step-wise regression analyses were conducted utilizing the BMDO4R program with achievement, attitude toward the instructional method and attitude toward science as criterion variables. Second, comparison between high and low achievement, attitude and success groups were made using step-wise discriminant techniques via the BMDO4M program.

Results of the regression analysis indicated that significant, but small amounts of variance were explained on each criterion. Achievement was most nearly related to CEEB mathematics scores; masculinity, restraint, ascendance and attitude toward instruction exhibited secondary associations. A total of 23.2% of the achievement variance was accounted for by the battery. Less than 20% of the variance on attitude toward science and instructional mode was explained. Instructional attitude was closely related to personality, particularly ascendance, while CEEB mathematics was the best predictor of attitude toward science. Moreover, the two attitudes were highly interrelated.

Discriminant analysis uncovered significant relationships for each criterion variable, yet most of the variance was associated with a single predictor variable. For achievement, attitude toward the method and success, respectively, these predictors were CEEB verbal, emotional attitude toward science and CEEB mathematics.

Post hoc predictions, based on the discriminant functions, indicated that low groups on each criterion were more readily identified than high. The functions correctly assigned 94% of the low achievers and better than

75% of the low group membership on the other factors. Pronounced differences were found between achievement and attitude indicating that they are relatively independent dimensions. The most discriminating indices included CEEB scores and scientific attitudes. Attitude toward the method was of secondary importance while the influence of personality factors, with the exception of masculinity and restraint was slight.

Significance: Since the discriminant analyses indicated that low group membership had high post hoc predictability, particularly with respect to achievement, the battery and statistical technique might provide a useful means of identifying students for whom the A-T method is an inappropriate instructional alternative.

When an A-T program is implemented, an instructional alternative should be available to students who would be predictably unsuccessful in the independent format.

FOUR-YEAR FOLLOW-UP ON PHYSICS STUDENTS

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Methods and Data Sources: In April 1972 an eight-page questionnaire was mailed to the home addresses of 3150 students who had been involved in the comparative evaluation of the Project Physics Course and other courses in 1967-68. Only 350 envelopes were returned as non-deliverable. Of the 280Q delivered, replies were returned by 1603, or a remarkable 57% response.

The questionnaire included some biographical information about recent activities: academic study, employment, military service, etc. Of the other three sections, two were identical with data-gathering devices used in 1967-68. One was two sheets of the semantic differential test on the topics: Physics, and Universe. The other was the Pupil Activity Inventory, now relabeled as the Participant Activity Inventory. The third sub-test deals with Science and Society and consisted of twenty items on ten topics presented in both positive and negative forms.

Data from these responses was treated to examine possible bias of the sample responding. From data recorded four years earlier the replies were considered in terms of: sex of student, career interests, physics course taken, teacher, academic activity, and geographical region. Individuals were compared with themselves four years earlier on various parameters and groupings.

CONCURRENT SESSION VIII

Session VIIIa - Discussion Paper, Statler 1

Chairman: Eugene C. Lee, Emory University, Atlanta, Georgia

1. "Elementary Science Curriculum and Student Achievement." Ben A. Smith, Oak Lawn Community High School, Oak Lawn, Illinois.

ELEMENTARY SCIENCE CURRICULUM AND STUDENT ACHIEVEMENT

Ben A. Smith
Oak Lawn Community High School
Oak Lawn, Illinois

Objectives: The purposes of this study were to (1) compare the growths in science achievement of 4th, 5th, and 6th grade students enrolled in six of the elementary-science curricula used in Southwestern Michigan, (2) determine the relationships that might exist among certain student variables (students' ranking in class, type of school, sex) and growth in student achievement, and (3) the relationships that might exist among teacher variables (pre-service science training, post-baccalaureate training in science, perception of curriculum, experience with curriculum, experience in teaching, perception of student ability) and growth in student achievement.

Method and Data Sources: Data were obtained by testing approximately 2,000 elementary-science students from 16 schools, representing 68 teachers and 77 classrooms in Southwestern Michigan during the 1971-72 school year with pre- and post-tests of science achievement. The test used was the "Science" section of the Educational Development Series of the Scholastic Testing Service. The characteristics of teachers were identified by administration of a questionnaire.

Results: The principal findings of the study were these:

1. In general, students who used the Silver Burdett series or Harcourt Brace and Jovanovich series had significantly greater gains in science achievement at all grade levels than did students who used the "modern curricula."

2. Students in the lower quarters of their classes who used the Silver Burdett series and the Harcourt Brace and Jovanovich series had significantly greater gains in science achievement than students in the upper quarters.

3. The type of community (urban, suburban, rural) does not seem to be related to the growth in science achievement of students in any of the programs dealt with in this study.

4. Student growth in science achievement seems to be independent of the sex factor.

5. Generally, the growth in science achievement of students whose teachers had 10 or more semester hours of pre-service science training was significantly greater than that of students who had teachers who completed fewer semester hours. An exception was found with SAPA where students who had teachers with less than 10 semester hours of pre-service science training made significantly greater gains than did students who had teachers with more than 10 semester hours of science training.

6. Students who had teachers with at least 3 semester hours of post-baccalaureate training in science made significantly greater gains in science achievement than students who had teachers with less than 3 semester hours of post-baccalaureate training.

7. Students of teachers who were dissatisfied with the quality of the curriculum they were teaching made significantly smaller gains in science achievement than students who had teachers who had positive views of the curriculum they were teaching.

8. An inverse relationship was found between the growth in science achievement of students and the teacher's experience in teaching the curriculum. Students who had teachers with less than 5 years experience in teaching the curriculum made greater gains in achievement than students who had teachers with more than 5 years experience.

9. It was found that students who had teachers with a total of 10-14 years of teaching experience made significantly greater gains in science achievement than students who had teachers with less than 10 years experience and those with more than 15 years experience.

10. The gains of students whom the teachers classified as having lower ability at the time of the pre-test were significantly smaller than the gains of students the teachers had classified as having higher ability.

Session VIIIb - Curriculum, Statler 2

Chairman: James Gallagher, Governors State University, Forest Park South, Illinoi

1. "A Survey of Science Teaching in the Public Elementary Schools of Two Selected Regions of the United States During the 1970-1971 School Year." Jerrold W. Maben, Herbert H. Lehman College, Bronx, New York.
2. "A Study of Content Development in Selected Secondary Biology Classes." Betty J. Stoess, Eastern Kentucky University, Richmond, Kentucky.
3. "An Analysis of Factors Successful in the Implementation of Innovative Science Programs in the Elementary and Secondary Rural Schools." Will L. Selser and Don Q. Milliken, Northeast Missouri State University, Kirksville, Missouri.

A SURVEY OF SCIENCE TEACHING IN THE PUBLIC ELEMENTARY SCHOOLS OF TWO SELECTED REGIONS OF THE UNITED STATES DURING THE 1970-1971 SCHOOL YEAR

Jerrold W. Maben
Herbert H. Lehman College
Bronx, New York

Objectives: The major problem of the study was to obtain information about the science teaching practices, procedures, policies and conditions prevailing during the 1970-1971 school year in the public elementary schools in two geographic regions of the United States. The study was one part of a six-part national survey of elementary and secondary school science. The two regions studied were the Central States, (Illinois, Indiana, Michigan, Ohio and Wisconsin) and the Far West States (Alaska, California, Hawaii, Nevada, Oregon and Washington). Sixteen sub-problems related to elementary school science programs, science budgets, science faculty, instructional procedures in science and science facilities were investigated.

Methods and Data Sources: The design of the study included a three stage sampling procedure to randomly select a sample of over 3,000 elementary schools in the eleven states of the two geographic regions. Two structured questionnaires were sent to principals of the randomly selected schools. Principals randomly selected one of the teachers who taught science in their school to receive the teacher questionnaire. One science class was randomly selected by the teachers to obtain certain data for the teacher questionnaire. Determination of responding and non-responding schools was made.Follow-up was conducted.

Results: Conclusions from the data were made relative to regional and state data and to school enrollment size. Particular attention was given to significant similarities and differences in three areas: 1) the academic preparation of the elementary school teachers who taught science; 2) practices related to school organization, teaching procedures and facilities for science instruction; and 3) funding for elementary school science. Trends in elementary school science were identified.

A STUDY OF CONTENT DEVELOPMENT IN SELECTED SECONDARY BIOLOGY CLASSES

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Objectives: The principal problem was to determine the interactive processes used by a sample of biology teachers in developing biology content with students in their classes. Sub-problems were: (1) determining teaching patterns for individual teachers and for the sample and (2) determining differences and similarities for teachers, days and class sections in the use of various categories of the category system employed.

Methods: Eight teachers were audiotaped on three consecutive days during two taping periods. Two lecture-discussion lessons were recorded each day. Sixty-four lessons (those recorded on the second and third days) were analyzed.

Each audiotaped lesson was encoded using the Content Analysis System for Chemistry, a system for categorizing content related verbal behaviors. (A preliminary investigation showed the system to be suitable for the study.) Three codes were assigned each unit of behavior: (1) an Initiate-Supply code, (2) a Semantic category code, and (3) a Syntactic subcategory code. The unit of behavior coded was the "content event."

Data Sources: Percentage values for the various categories and subcategories were obtained for each lesson using the BMD-02S Contingency Table Analysis Program. The BMD-02V Analysis of Variance for Factorial Design program was used for testing five hypotheses. A third program provided a series of first order transition matrices. Included were Initiate-Supply transitions (4 x 4), Syntactic sub-category transitions (13 x 13), and the combination of these two 52 x 52) for the composite sample and for each teacher.

Results: Results of the study indicated a deductive approach to content development that was highly teacher-dominated. Teachers initiated the majority (93.4 percent) of content events and supplied three times as many events as students did. The average teacher relied heavily (approximately 50 percent) on lecture. The pace of discussion was brisk, averaging three content events per minute.

Teachers most often sought predictable, factual responses from students, generally Identifying in nature. By contrast, students most often sought Amplification from teachers. Student responses were typically short and never as expanded as teacher discourse. Except for Personal Examples, students did little Exemplifying. Examples provided by teachers were most often Concrete Examples. Few content events were judgmental in nature. There was little use of either the Background or Disgression categories. Most content events were concerned with developing the Figure.

The most frequently occurring teaching pattern, common to six teachers, was Describing and Designating some Concrete Example. Other patterns were Inferences followed by a Concrete Example and a series of Designating and Describing events.

Hypothesis testing revealed few significant relationships among teachers or days or between class sections with respect to the number of content events per lesson, and to the percentages of content events coded in the various categories and sub-categories of the CASC instrument.

Significance: The study substantiated some findings of earlier research on verbal interaction in science classes, namely Balzer (1968), Ramsey (1969), and Parakh (1965, 1968). The identification of three distinct teaching patterns, despite few significant relationships evidenced in hypothesis testing, indicates the value of examining the sequence of verbal operations.

AN ANALYSIS OF FACTORS SUCCESSFUL IN THE IMPLEMENTATION OF INNOVATIVE SCIENCE PROGRAMS IN THE ELEMENTARY AND SECONDARY RURAL SCHOOLS

Will L. Selser

and

Don Q. Milliken
Northeast Missouri State University
Kirksville, Missouri

Objectives: This study attempts to identify factors which have been successful in the implementation of innovative science programs in the science classrooms of the public schools in rural areas of northeast Missouri. Attention was directed to the following teacher factors: (1) college academic science preparation of the teachers, (2) college method courses, (3) teacher participation in special institutes or (4) innovative workshops, (5) the teachers' feeling of adequacy, and (6) the effect of the administrators' encouragement and financial support in implementing the newer programs. Administrative factors considered were (1) degree of enthusiasm for innovative programs, (2) financial support, and (3) community involvement in science as a mitigating factor.

Method and Data Sources: The sample was drawn from the 180 elementary schools and the 111 secondary schools within the 25 counties of northeastern Missouri. A random sample of 30 elementary schools and 30 secondary schools was selected for investigation. At least one elementary and one secondary school was selected from each county in northeast Missouri.

Procedure included written questionnaires for secondary and elementary science teachers and administrators. Additional in-depth questionnaires and personal interviews were administered to randomly selected science teachers. The data were analyzed by step-wise multiple-regression technique.

Results: Analysis indicates that college academic science and methods courses were largely ineffective in the implementation of the new innovative programs listed in the questionnaire. The college science and methods courses resulted in a feeling of inadequacy for one-fourth of the teachers and a feeling of only average preparedness for an additional 52 percent. Interviews with administrators support this lack of confidence and preparedness. College courses are not providing effective information about new programs. There is a high degree of correlation between the teachers feeling of adequacy and willingness to implement innovative teaching technique in the science classroom. In the implementation of the new curricula there is good correlation between administrators with science backgrounds and young teachers recently involved in innovative workshops.

At the secondary level 10 percent of the teachers used an innovative curriculum, although 50 percent used some part of these materials for one or more classes per day. Money for supplies and equipment was a critical factor. Regular college level programs did not furnish teachers with innovative curricula.

Significance: Successful factors in implementation of new curricula are the enthusiasm of the individual teacher, the cooperation of the administrator, and the post-service workshop. The data support need for (1) a different type of academic and methods curricula for science teachers in our region, (2) a series of seminars or workshops to acquaint administrators with the potential and impact of the new programs, and (3) a revision of our in-service programs which would stress the teaching of new curricula.

Session VIIIc - Instructional Procedures, Hilton 1

Chairman: Kenneth Jerkins, Morgan State University, Baltimore, Maryland

1. "A Study of the Effects of A Reading Method VS. An Activity Method On the Learning and Retention of Simple Concepts Dealing With Pendulums." Dale G. Merkle, Shippensburg State College, Shippensburg, Pennsylvania.
2. "The Effectiveness of Cue Fading in Teaching Kindergarten Children To Serial Order." Larry E. Schafer, Syracuse University, Syracuse, New York.
3. "A Study of the Effects of Information Items On Snyder's 1968 Proto-Theory of Instructional Efficiency as Applied to a Genetics Problem-Solving Situation." J. Wesley Bahorik, Kutztown State College, Kutztown, Pennsylvania and H. Seymour Fowler, Pennsylvania State University, University Park, Pennsylvania.

A STUDY OF THE EFFECTS OF A READING METHOD VS. AN ACTIVITY METHOD ON THE LEARNING AND RETENTION OF SIMPLE CONCEPTS DEALING WITH PENDULUMS

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Shippensburg, Pennsylvania

Objectives: The research described herein was a simple attempt to involve the graduate students in an elementary school science education course, first hand, in an actual test of two methods of learning; inquiry activities and reading. The students were the subjects of the study. It was hoped that having action research applied to them would be effective motivation to help them understand the importance of using inquiry activities to teach science in their classrooms.

Methods and Data Sources: Two intact graduate elementary science classes were used in the study: (1) a group of twenty-three inservice teachers in a six weeks summer class, and (2) a group of thirty-one inservice teachers in an eleven weeks term.

Prior to the first session the names on the class lists were randomly divided into two groups of approximately the same size. A short examination on pendulums was constructed. This test was given to the members of each class shortly after their entry on the first day of class. No preparation was allowed and no advance warning was issued. The classes were then divided into the two groups as selected randomly. One group was directed to use the college library to study about pendulums employing the texts and references of the curriculum library for the next hour. The other group remained in the classroom and used the materials from the Elementary Science Study unit on pendulums. Thev collected data and analyzed the results of their inquiry activity without teacher direction.

Both groups were then brought back into the classroom, and a posttest was given. During the following class session the results of this data were shared with the students. The postulate that "activity on the part of the learner is preferred to passivity" was discussed. The fact that the newer national curricula in elementary science education advocate this point of view and reflect this postulate in the construction of these curricula was explained.

No further reference to these tests or the pendulum activity was made during the remaining portion of the term. At the next to last session of the class, a post-posttest was given to secure data regarding the retention of knowledge concerning pendulums. Pretest, posttest, and post-posttest comparisons were made between the Reading (R) group and the Activity (A) group using the t-test.

Results: The table value for t at twenty-one degrees of freedom and alpha level of 0.05 is 2.080. The posttest and post-posttest comparisons indicate a significant difference in the scores for the two groups. The activity group achieved significantly higher than the reading group on these measures. The pretest comparison indicates no significant difference between the two groups on this test prior to the treatment. Learning and retention on the part of the activity group appear to be significantly better after the activity and after six weeks of time.

The table value for t at twenty-nine degrees of freedom and alpha level of 0.05 is 2.045. The posttest comparison indicates a significant difference. The activity group scored significantly higher on the pendulum test than did the reading group. The post-posttest does not give a significant difference. This may be interpreted to mean that after ten weeks of forgetting time, the amount of retention does not differ significantly in the two groups.

In both test group situations the amount of learning that took place as indicated by posttest scores shows a superior learning experience for the activity group as compared to the reading group.

This activity gave both inservice teacher groups a positive example of the use of inquiry activities in teaching science.

THE EFFECTIVENESS OF CUE FADING IN TEACHING KINDERGARTEN CHILDREN TO SERIAL ORDER

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Objectives: Serial ordering, defined concretely as the ability to order objects (for example, sticks of different lengths) according to a specific attribute (length), is a fundamental intellectual capability that is inextricably related to elementary science teaching (SAPA and SCIS programs). The child's understanding of time-space and cause-effect relationships must involve concepts of order. Furthermore, serial ordering can be used to organize information for the purpose of discovering relationships. For example, just as Mendeleef serial ordered chemical elements according to atomic weights and observed the periodic reoccurrence of similar physical and chemical properties, a young child could order plants according to some treatment variable (total time exposed to light) and then more easily discover how other plant characteristics relate to that treatment variable.

Can the experiences of young children be governed in ways which facilitate their acquisition of science related intellectual capabilities? Evidence to the affirmative is accumulating. The purpose of the work described here was to investigate the effectiveness of one method (cueing and cue fading) of helping kindergarten acquire, retain, and transfer the ability to serial order.

Methods and Data Sources: According to Piaget, a child's ability to order develops in three stages. During the second stage, the child (age 5) orders objects by trial and error but fails to correctly insert a disordered set of objects into an ordered set so that all the objects are ordered. In the third and final stage the child (age 6 or 7) both orders with ease and correctly inserts objects into an ordered set.

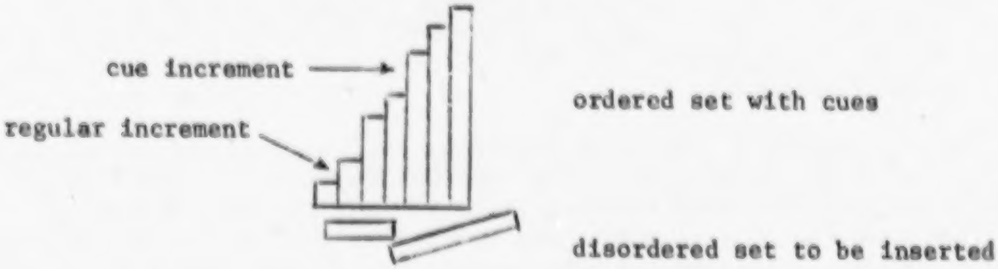
The primary purpose of the instruction was to help children in stage II acquire the stage III capability of inserting objects into an ordered set. Thirty-four stage II children, identified by their performances on a serial ordering pretest, were randomly assigned either to a control group, which received no formal instruction, or to an experimental group, which received instruction in stage III capabilities.

Each experimental subject was individually given approximately 30 minutes of instruction on each of three consecutive days. The instruction consisted of having the children perform a rather large number of tasks in which a disarranged set of objects had to be inserted into an ordered set. The tasks were sequenced from the least difficult (few objects, no fine discriminations required) to the most difficult (many objects, fine discriminations required), and the children had to meet performance criteria before moving from one difficulty level to the next.

In addition, different materials were used in the training to facilitate transfer, and both verbal and material reinforcers were used primarily to keep the children at the tasks.

Since there is evidence suggesting that children fail to perform certain cognitive tasks because of an inability to attend to the relevant task dimensions, cues were used to help the children focus on the relevant aspects of the tasks. As the children acquired the ability to insert, the cues were gradually faded out leaving the children with the ability to perform the tasks unaided.

For example, when sticks were used in the instruction, the cues appeared in the ordered set of sticks (see figure). In the ordered set, the sticks increased in regular increments except for those places where a stick should be inserted. At those places, the increment was comparatively large, giving the impression that a stick was missing. The cues were faded in five steps by reducing the large increments to the regular increments.



Posttests were given approximately one, eight, and 132 days after instruction. Each posttest consisted of both near and far transfer measures. The materials used in the near transfer measure were similar to those used in instruction, whereas the materials used in the far transfer measure were unlike those used in the training.

Results: The results of repeated measures analyses revealed that the experimental children acquired and retained (at least 132 days) the specific target capabilities of the instruction (near transfer data). However, the analyses also revealed that the children's ability to transfer those acquired capabilities (far transfer data) appeared only at the time of the second posttest (explanations for the experimental group's unexpected far transfer performance have been contrived). In addition, a group of students who were already in stage III before the beginning of the experiment were given the third posttest and were found to perform no better than the experimental children who began with stage II capabilities and acquired some stage III capabilities as a result of the instruction.

Significance: The results of this study seemingly indicate that the development of the serial ordering capability can be influenced by instruction. Conceivably, the findings set the stage for future research which might probe into the specific effects of such instruction on children's subsequent performance in science activities and subsequent development of certain intellectual capabilities.

A STUDY OF THE EFFECTS OF INFORMATION ITEMS ON SNYDER'S 1968 PROTOTHEORY OF INSTRUCTIONAL EFFICIENCY AS APPLIED TO A GENETICS PROBLEM-SOLVING SITUATION

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and

H. Seymour Fowler
Pennsylvania State University
University Park, Pennsylvania

Objectives: This research investigated the applicability of Snyder's 1968 prototheory of instructional efficiency to a genetics problem-solving situation. "Part One of the Problem" involved a test of the equivalence of the revised formula, $\hat{s}_I = t_I/s_I$, to Snyder's (1968) formula for the mean number of transactions needed by a teacher-student dyad to solve the stages of a problem; or, $\hat{s} = t/s = 1$. "Part Two of the Problem" utilized a test of the equivalence of the revised ratio, $\hat{S}_I = S_I/T_I$, to Snyder's (1968) formula for the mean number of trials needed by a teacher-student dyad to solve a problem; or, $\hat{S} = S/T = 1$.

Three subproblems were investigated: (1) the effect of the number of information items contained in the task, (2) the effect of the amount of "learning structure" in the problem-solving situation, and (3) the prediction that the most efficient task group would be the group exposed to the least amount of "learning structure", and, having access to the lowest number of information items.

Methods and Data Sources: One hundred twenty subjects from the sixth grade in three Pennsylvania schools were administered a genetics problem-solving task. Four task groups were formed by randomly assigning variations of the task to the subjects. The task varied in number of information items presented and amount of "learning structure" employed. All information items and the genetics problem were presented to the subjects by a researcher-constructed machine. Students' responses to the task were recorded by the machine. Verbal expressions of the students were tape-recorded.

The comparison of the revised formulas to Snyder's 1968 ratios was accomplished by comparing the computed efficiency values obtained for the four tasks to Snyder's 1968 predictions.

The design to test the effects of the number of information items was a comparison of the performance of eight-hint task groups to four-hint task groups. The design for testing the effects of "learning structure" was a comparison of the performance of mandatory item reading groups

to free selection task groups. The chi-square and analysis of variance techniques were employed to analyse these subproblems.

Results: The most important result of this research was the suggested equivalence of the ratio $\hat{s}_I = t_I/s_I$, as a measure of instructional efficiency, to Snyder's ratio $\hat{s} = t/s = 1$.

The results of the subproblems indicated no significant differences among the variables among the task groups compared.

Significance: The main finding supports the notion that Snyder's 1968 prototheory of instructional efficiency may be applied to formal problem-solving situations. The equivalence of $\hat{s}_I$ and $\hat{s}$ opens new avenues of science education research.

The findings under "subproblems" indicate the number of information items and the instructional strategy, "learning structure," imposed by the "teacher" had no effect on the performance of the subjects. The subjects adopted "their own" strategy and found "their own" set of "critical" information items.

The use of the researcher-constructed machine aided this research by reducing error due to inconsistency or personal bias on the part of a live teacher-researcher.

Session VIIId- Evaluation, Hilton 3

Chairman: Robert Bridgham, Stanford University, Stanford, California

1. "New Methodology for Test Construction and Course Evaluation." Glen S. Aikenhead, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.
2. "The Modification and Local Use of the National Assessment Test Science Items By the Del Mod System." John R. Bolig, Del Mod System, Dover, Delaware.
3. "An Analysis and Classification of The ACS-NSTA High School Chemistry Achievement Tests, Using Bloom's Taxonomy---Cognitive Domain." Kenneth V. Fast, Webster Groves, Missouri.

A NEW METHODOLOGY FOR TEST CONSTRUCTION IN COURSE EVALUATION

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Saskatoon, Saskatchewan

Objectives: This study proposes and demonstrates a new test construction methodology: general and valid instruments are utilized by empirically selecting items which prove to be most appropriate to a certain course.

Methods: The empirical selection is accomplished by item analysis. The McNemar chi-square statistic identified items which experience a statistically significant change in student response between a pretest and posttest administration of general and valid tests. These items may be combined into one or more instruments.

Data Sources: This new methodology for constructing tests successfully led to a unique evaluation instrument for Project Physics. The Test on Understanding Science (TOUS) and the Science Process Inventory (SPI) were used as general sources of items. The students who responded to these tests were part of the 1967-68 nation-wide evaluation of Project Physics. A random subsample of 921 students, those writing both the pretest and posttest of the TOUS or SPI, served as sources of data. A second and independent random subsample of sixty-four students supplied the necessary data to describe the statistical attributes of the derived evaluation instrument.

Results: This instrument, "A Measurement of Knowledge About Science and Scientists (project Physics: Form 1)" abbreviated KASSPP1, had a greater predictive validity for Project Physics than either the TOUS or SPI. This increased predictive validity would tend to yield a greater amount of feedback to a curriculum developer and teacher because the derived test would tend to show more change in student knowledge than the parent instruments.

Significance: Test validity has always been a prime concern to an evaluator. The KASSPP1 is validated upon the actual learning accomplished by Project Physics students, as opposed to the Learning hoped for by teachers and curriculum developers. The development of such tests, and the tests themselves, have their greatest application to formative evaluation. The new methodology in test construction can be used with any valid instruments and applied to any pertinent educational experience.

THE MODIFICATION AND LOCAL USE OF THE NATIONAL ASSESSMENT TEST SCIENCE ITEMS BY THE DEL MOD SYSTEM

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Del Mod System
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Objectives: The Del Mod System[1] modified the National Assessment Test of Science for seventeen-year olds as reported by Womer[2]. The outstanding modification, testing intact high school senior classes, facilitated test administration greatly. The results of the modification were gratifying. Delaware scores on each item were quite similar to those reported nationally.

Methods and Data Sources: Fifty of the fifty-four items released by the Education Commission of the States were used in Delaware. The four deleted items require equipment to measure a scientific process and were deemed too time consuming.

The fifty-item test was administered to a total of 1187 seniors in five different Delaware high schools. The schools were randomly selected until two criteria were met: one of the schools had to be an inner-city school, and a total sample of more than 1000 students had to be tested.

Results: An outstanding result of this test was the disparity between sexes. This result duplicated the national results, a fact which was not stressed by Womer. Boys out-scored girls on almost all of the items. A Del Mod follow-up study for causes of result determined that more males than females had enrolled in high school science classes. Enrollments in physics classes, for example, were almost four to one male over female in Delaware high schools. In those instances where girls had the same number of science courses as boys, the differences were negligible.

Significance: The use of this test and its results have had an impact upon reevaluation of the Del Mod System. A prime objective of future Del Mod projects will involve the necessity of equalizing sex differences in Delaware schools, both for enrollments in science classes and for science achievement.

Of secondary significance is the evidence that the National Assessment Test items can be administered to intact classes with great efficiency. The education Commission of the States should report normative data by grade level as well as by age. Grade-level data would make the test more appealing as an achievement-measuring instrument. Very few schools are willing to administer the test under the clinical conditions exercised by the Education Commission of the States.

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[1] Purnell, C. P., "The Del Mod System: A Systems Approach to Science Education," The Science Teacher, Vol. 39, No. 6, Sept., 1972.

[2] Womer, F. B., National Assessment of Educational Progress, A Project of the Education Commission of the States, Report 1, 1969-1970 Science: National Results and Illustrations of Group Comparisons, U. S. Government Printing Office, Washington, DC 20402, July, 1970.

AN ANALYSIS AND CLASSIFICATION OF THE ACS-NSTA HIGH SCHOOL CHEMISTRY ACHIEVEMENT TESTS, USING BLOOM'S TAXONOMY---COGNITIVE DOMAIN

Kenneth V. Fast
Webster Groves, Missouri

Objectives: The questions addressed by this study were:

1. What percent of the test items in the chemistry tests examined is represented by each level of the Taxonomy?
2. Do the more recent tests contain a greater percent of the higher cognitive level test items than the earlier tests?
3. Do the advanced series tests contain a greater percent of the higher cognitive level test items than do the regular tests?
4. Do the items in higher cognitive level classifications represent greater difficulty than those in lower levels of classification?
5. Do the items in higher cognitive level classifications show more discrimination than those in lower levels of classification?

Methods and Data Sources: A total of 955 items were classified according to cognitive levels (Bloom's). Each test was described according to the number of items at each cognitive level. Validation of the investigator's ability to classify test items was based on the percent of agreement on a sample set with those of a judging panel.

Pretest forms and item analysis data were procured on each item in order to make comparisons of the difficulty and the discrimination with the cognitive level classifications. These values, as well as percent of omits, were reported on each item. Difficulty and discrimination indices averages were presented for the twelve tests.

Results: The ACS-NSTA High School Chemistry Tests contained items in the following proportions: Knowledge, 40.2%; Comprehension, 25.6%; Application, 24.8%; and Analysis and/or above, 9.3%. No Synthesis level item was identified. The six most recent tests contained a greater percentage of higher cognitive level items than did the six earlier tests. The average percent of Analysis items in the advanced series was 13.7% as compared to 7.7% in the regular tests. The difficulty of the items increased with the hierarchy of the Taxonomy levels. The discrimination index averages indicated the Application level items were the most discriminating. Application level items were most frequently omitted.

Conclusions and Significance:

1. Either the 1969 Regular Form or the 1966 Advanced Form of the ACS-NSTA High School Chemistry Examination should be used as a model for teachers and test makers who wish to develop tests to measure learning according to Bloom's first four categories. These forms have a balanced distribution of items among the first four levels of the Taxonomy.

2. Many of the 908 unused items from the twelve high school chemistry pretest forms have acceptable item analysis statistics. These items should be classified according to the cognitive levels and used in other tests.

3. Since Synthesis and Evaluation level items were notably absent in the 955 items classified, serious consideration by test makers should be given to the development of tests other than the forced choice format. By so doing, measurements at these higher cognitive levels will be available.

4. Items from the ACS-NSTA retired tests and the unused pretest items that have item analysis, content analysis, and Taxonomy classification should be placed in a computer storate bank from which individual and classroom examinations could be constructed.

5. Cognitive level classifications should be made on other chemistry and other science tests to determine the extent to which the Taxonomy levels have been covered.

6. Future studies should be made in the development and classification of chemistry and other science test items in the affective domain.

CONCURRENT SESSION IX

Session I a - Panel, Statler 1

"New Vistas For Research: The Effect of Facility Design On Science Teaching and Learning"

Chairman: David Engelhardt

Participants: David Engelhardt, Engelhardt and Engelhardt, Inc., Purdy Station, New York.

Heidi Kass, The University of Alberta, Edmonton 7, Canada.

Joseph D. Novak, Cornell University, Ithaca, New York.

NEW VISTAS FOR RESEARCH: THE EFFECT OF FACILITY DESIGN ON SCIENCE TEACHING AND LEARNING

David Engelhardt
Engelhardt and Engelhardt, Inc.
Purdy Station, New York

Heidi Kass
The University of Alberta
Edmonton 7, Canada

Joseph D. Novak
Cornell University
Ithaca, New York

A new type of panel discussion is being tried this year, with the hope that a series of discussions might evolve for the annual NARST meeting. The series, entitled "New Vistas for Research" is to provide:

1. Feedback from educational practitioners to members of the "rigorous" research community. (This feedback should provide opportunity for constructive efforts fostering research endeavors which are relevant to the needs of the practitioner.)

2. Better receptivity and utilization of research findings by the prospective consumer of research. (Since feedback from practitioners will have occurred, hopefully the research community has responded with helpful analysis of problems for which there is high concern.)

3. Input from outside the normal communication network in science education research.

4. A forum which may generate cooperative projects in large, significant areas of need. (For researchers who have primarily non-research positions, this should provide an opportunity to contribute some research talent to the investigation of significant problems. Funding and dissemination aspects can be discussed by interested members following the panel discussions.)

As a science facility consultant, Dave Engelhardt will discuss the consumer's need for research in science facilities. Briefly referencing his past research on teacher behavior and facilities, Dave will suggest some theoretically interesting concepts which might provide researchable topics. Heidi Kass, also having experience with the design of science teaching facilities, is concerned with student learning outcomes as a science educator. She comes from a university internationally respected for its department of educational administration and also resides in an area of high enrollment growth with resultant building needs. She will review the response of science researchers to the knowledge needs of administrators and consultants in a geographical area of high need. Joe Novak shall comment on the state-of-knowledge in the facility design field in reference to his experience as Director of the NSTA Science Facilities Study. He shall critique Dave Engelhardt's ideas concerning systematic study of issues and suggest some approaches to solving the need for evaluative knowledge in this field. Viable and interesting approaches obtain some models for ecological research and ethological studies. Audience participation will be invited.

A review of literature will be attempted at the meeting. A bibliography for those who wish to read about the subject prior to the meeting is available by writing Dave Engelhardt. ERIC Documents which would provide background of Engelhardt's views are ED 022 353, 024 214, SE 008 245, and especially ED 045 397. A short book presenting an argument for spatial research is Robert Sommer's Personal Space: The Behavioral Basis of Design (chapters 1-5, 7, and 11). Some other references touching our concern are chapter 7 in Seymour Sarason's The Culture of the School and the Problem of Change; the preface and Peter Manning's chapter in Proshansky, Harold M., W. H. Ittelson, and L. G. Rivlin's (eds.) Environmental Psychology: Man and His Physical Setting; R. G. Barker's Ecological Psychology; Howard Wakefield and Byron C. Bloomfield's article "Facilities: Environment of Learning" in the 1969 Britannica Review of American Education.

Session IXb - Panel, Statler 2

"A Comparative Study of Teaching Strategies in School Science Program."

Chairman: James A. Shymansky

Participants: James A. Shymansky, Florida State University, Tallahassee, Florida.

Charles Matthews, Florida State University, Tallahassee, Florida.

Ron Good, Florida State University, Tallahassee, Florida.

John Penick, Florida State University, Tallahassee, Florida.

Pat Kolebas, Florida State University, Tallahassee, Florida.

A COMPARATIVE STUDY OF TEACHING STRATEGIES IN SCHOOL SCIENCE PROGRAMS

James A. Shymansky
Charles Matthews
Ron Good
John Penick
Pat Kolebas
Florida State University
Tallahassee, Florida

Objectives: Presently underway is a cooperative research project involving the Florida State University Department of Science Education and selected members of the instructional staff of the Florida State Developmental Research School. This project is designed to investigate the effects of two contrasting sets of learning conditions or instructional strategies on certain aspects of the behavior of students in school science (grades one through five and high school chemistry). Defining the learning conditions in a science classroom in terms of three factors---school plant, learning materials, and teacher behavior, attention is focused on the teacher's behavior by holding constant the school plant and learning materials. Specifically, the effects of directive and non-directive patterns of teacher behavior on student behaviors are being studied. Telling students what activity to do or how to do it followed by some form of feedback defines a directive pattern of teacher behavior in the study.

Methods: During the summer of 1972 a workshop was conducted at the Florida State Developmental Research School in which the participating teachers were given the opportunity to review the rationale of the two contrasting sets of learning conditions and to practice the teaching behaviors required to establish each set of conditions. The two sets of learning conditions or instructional strategies are referred to as "Teacher Structured Learning in Science" (TSLS) in which the teacher exhibits directive behaviors and "Student Structured Learning in Science" (SSLS) in which the teacher exhibits non-directive behaviors.

To facilitate the establishment of the TSLS and SSLS learning conditions, the teachers were given instructions in the use of the SCAS Classroom Interaction Categories - Teacher Behaviors. The ratio of the teaching behaviors classified as directive in the SCAS categories (Categories 4, 5, 6, and 9) to the total of all teaching behaviors exhibited during a science lesson provide a basis for comparing the degree of directiveness and non-directiveness in the TSLS and SSLS classrooms (this ratio is referred to as the Learning Conditions Index (LCI).

Data Sources: The study involves approximately 300 students in grades one through five and high school chemistry. Among the data being collected are those dealing with the cognitive characteristics of the students using Piagetian-type interviews, student creativity using the Torrence tests, student attitudes toward science and themselves, student problem solving abilities, and student classroom behaviors. In all cases except student classroom behavior, pretests were administered in order to study possible changes in student performance in the TSLS and SSLS learning conditions.

Results: Analysis of observational data on student behaviors in the classroom will reveal any differences in student behaviors caused by the contrasting levels of teacher directiveness in each set of learning conditions. In addition to providing baseline data for studying changes in cognitive development, the Piagetian-type interview scores will be used to group students in the sample for further analysis of observational and other test data.

Session IXc - Curriculum Evaluation, Hilton 1

Chairman: F. James Rutherford, New York University, New York City, New York

1. "Analysis Of Field Testing Individualized Chemistry in Florida." Paul A. Becht, University of Florida, Gainesville, Florida.
2. "The Readability of the E.S.C.P. Textbook." Mary Christelle Sawicki, Villa Maria Convent, Buffalo, New York.
3. "The Relationship Between Certain Structure-Of-Intellect Abilities and Achievement In A Selected Sequence From the Conceptually Oriented Program In Elementary Science." Leon L. Ukens, Towson State College, Baltimore, Maryland.

ANALYSIS OF FIELD TESTING INDIVIDUALIZED CHEMISTRY IN FLORIDA

Paul A. Becht
University of Florida
Gainesville, Florida

Objectives: During the past three years the science faculty at P. K. Yonge Laboratory School, University of Florida, have developed and field-tested an Individualized Chemistry Program in the public schools of Florida. This program is designed to give the student a better understanding of basic chemical concepts and relevant chemical applications through more individual contract with the teacher.

This study is designed to answer the following question: Can this program be taught effectively by chemistry teachers found in public schools in the State of Florida?

Methods and Data Sources: The sample for this study consists of 18 classes of students in the experimental program consisting of 849 students and 11 control classes consisting of 703 students for a total student population of 1552. The control and experimental classes were randomly selected from the pool of schools in the State of Florida that indicated a willingness to participate as an experimental or control school in the Individualized Chemistry study. The pool of schools were selected from schools in 44 Florida counties subscribing to the Florida Educational Research and Development Council (FERDC). These counties range from the Panhandle to the Southern tip of Florida and are representative of the State's population.

Three test instruments and one questionnaire were used for the evaluation of the study. They are as follows:

1. ACS-NSTA Cooperative Chemistry Exam

2. Sequential Test of Educational Progress Reading Test

3. Any School Subject Attitude Test

4. Student Questionnaire

Results: Four hypotheses were tested, three tested the significance of difference between the experimental and control groups and one tested the difference between slow and fast readers within each group. Results indicated no difference between groups with respect to achievement in Chemistry or reading ability but did indicate a positive difference toward the experimental group with respect to attitude and self concept.

THE READABILITY OF THE E.S.C.P. TEXTBOOK

Mary Christelle Sawicki
Villa Maria Convent
Buffalo, New York

Objectives: As educators we must acknowledge that the textbook, whether the traditional or programmed form, is alive, well and will continue to hold a strong position in determining the curriculum and course of study. However, it is obvious that textbooks have little educational value for students if they are difficult to read. The purpose of this study was to determine the readability of the textbook presently in use with the E.S.C.P. program.

Methods and Data Sources: Thirty samplings from the E.S.C.P. textbook, selected randomly from the front, middle and back sections of the textbook were used. The SMOG Index, recently developed by McLaughlin (1969), was applied to the samples, because it accounts for the regression analysis computed by earlier formulae as well as semantic and synctactic interaction. A correlation was computed to validate the use of the SMOG Index in determining the readability level of the samplings used in this study. The correlation established (.77) was significant beyond the .01 level of confidence, thus validating the SMOG Index as a statistically accurate instrument.

Results: Analysis of the grade level readability scores obtained in this study showed a wide range of readability levels for the E.S.C.P. textbook. (9 grade levels). Eighty percent of the scores showed a readability from two to five years beyond the level of the students for whom the book was designed. Twenty percent of the scores showed the book to be on grade level. The scores showed no progression from easiest reading material in the front part of the book to more difficult reading material near the end of the text.

Conclusions: It is obvious from the data obtained in this study that there is a tremendous need for research pointed toward the development of reading materials in science fitted to the reading ability of the students. A starting point in this direction is for us, as educators, to take a stand that will force publishers to provide reading materials in science which have been tested by valid statistical instruments rather than by an author's opinion. The development of reading materials in science which would cover the same principles and applications at several reading levels could also prove effective. The need for developing reading programs in the content fields is also implicit.

Significance: Too often the conceptual or aesthetic merits of a set of materials is given consideration to the complete neglect of whether the student will be able to read and comprehend the materials. Written materials have little educational value if they are written in a language that is so complex and obscure that students cannot understand them.

THE RELATIONSHIP BETWEEN CERTAIN STRUCTURE-OF-INTELLECT ABILITIES AND ACHIEVEMENT IN A SELECTED SEQUENCE FROM THE CONCEPTUALLY ORIENTED PROGRAM IN ELEMENTARY SCIENCE

Leon L. Ukens
Towson State College
Baltimore, Maryland

Objectives: The purpose of this research was to determine which of certain structure-of-intellect (SI) abilities were related to pupil achievement in the Mechanical Energy Sequence from the Conceptually Oriented Program in Elementary Science (COPES).

Method and Data Sources: Scores on SI tests covering 17 selected abilities were determined for the sample of 158 sixth grade students consisting of 84 boys and 74 girls. A pretest based on selected mechanical energy concepts, those prerequisite to this sequence, was also administered to this same sample. The Mechanical Energy Sequence was then taught by the participating teachers to their respective classes after which a posttest based on the concepts taught in the sequence was administered.

An analysis of the data was performed using a stepwise multiple regression analysis with the posttest scores serving as the dependent variable. The pretest scores served as the first predictor in each of three multiple regression analyses, one for the total sample, one for the girls separately, and one for the boys separately. At each step of the analysis an independent variable (SI test) was added and a new multiple regression coefficient determined. The addition of new independent variables ceased when the increase in the multiple regression coefficient failed to be significant at the .05 level of significance.

The final result for the total sample, for the boys separately and for the girls separately, was a multiple regression coefficient derived from the pretest with the addition of other significant SI variables. For the total sample, convergent production of semantic relations, convergent production of symbolic relations, convergent production of figural transformations, and divergent production of semantic transformations were found to be significant predictors of achievement on the COPES posttest.

Results: In comparing results between boys and girls, different but similar SI abilities were found to be significant predictors for each of these two groups. As with the total sample, convergent production thinking was found in a number of these abilities as was the three types of SI content.

The COPES Mechanical Energy Sequence is a structured science sequence leading (converging) to one main conceptual scheme, namely the conservation of mechanical energy. The activities in this sequence are designed to predispose this outcome. These results also indicate that the different kinds of content combined with convergent productive thinking provide more new information than would other kinds of thinking operations. Each of the types of content, semantic, symbolic, and figural, is present in the Mechanical Energy Sequence.

Significance: The results of this research can be applied to (1) establishing proper sequencing of the COPES materials on the basis of SI abilities, (2) providing the teacher with some insight into the kinds of instructional strategies that could be used, and (3) helping the teacher decide on the timing of the particular instruction.

Session IXd - Student Performance, Hilton 3

Chairman: Robert W. Howe, The Ohio State University, Columbus, Ohio

1. "An Analysis of Self Directedness In Relation To Performance in an Individualized Chemistry-Physics Course." Donald W. McCurdy, University of Nebraska, Lincoln, Nebraska.
2. "A Comparative Study of the Effects of Prior Knowledge of Performance Objectives on Cognitive Learning Outcomes in the Instruction of TCCP Physical Science." Clarence D. Coleman, Norfolk State College, Norfolk, Virginia and H. Seymour Fowler, The Pennsylvania State University, University Park, Pennsylvania.
3. "Identification of Performance-Based Objectives For Classroom Teaching Strategies." Robert L. Uffelman, University of Delaware, Newark, Delaware.

AN ANALYSIS OF SELF DIRECTEDNESS IN RELATION TO PERFORMANCE IN AN INDIVIDUALIZED CHEMISTRY-PHYSICS COURSE

Donald W. McCurdy
University of Nebraska
Lincoln, Nebraska

Objectives:

1. To conduct an analysis of the perception of students in the Nebraska Physical Science Project (an individualized course) relative to how they perceive their ability to direct their own learning activities.
2. To relate data on perceived self-directedness to relative degrees of success in the course.
3. To relate data on self-directedness to other variables such as sex and age.

Methods:

1. A Likert scaled instrument (Student Self-directedness Behavior Scale) was administered to two randomly selected samples of students who were judged by their teachers as being in the top 15% and bottom 15% (in terms of performance) of their classes.
2. Scores were derived on eight characteristics of self-directed behavior.
3. "t" tests and analysis of variance techniques were employed to analyze the data.

Data Sources: A stratified random sample of 95 students from a sampling frame of 350 students in the first year of the Nebraska Physical Science Project were tested during the last three weeks of the 1971-1972 academic year.

Results:

1. Students who performed in the upper strata of their classes were found to be significantly (.01 level of confidence) more self-directing (in terms of their own perceptions) with respect to the following variables than were those in the lower strata.

   a. Amount of teacher direction needed.
   b. Efficient use of class time.
   c. Ability to plan a work schedule.

   d. Use of basic study skills.
   e. Use of self-teaching curriculum materials and packages.
   f. Pace of learning.

2. The two groups were found not to differ significantly with respect to:

   a. adapting curricula by omitting unneeded activities.
   b. independently seeking answers to questions and problems.

3. There was no significant difference between the sexes in terms of their perceived self-directedness.

Significance: The results of this study imply that students have different learning styles. Some are capable of dealing with a greater degree of freedom in the classroom and more responsibility for their own learning whereas others may need more structure.

If students could be tested prior to enrollment in courses requiring a high degree of self-directedness, they could be counseled into or away from such courses. It is possible that the "Self-directed Behavior Rating Scale" could be used for this purpose. Verification of this hypothesis will require additional testing of this instrument.

A COMPARATIVE STUDY OF THE EFFECTS OF PRIOR KNOWLEDGE OF PERFORMANCE OBJECTIVES ON COGNITIVE LEARNING OUTCOMES IN THE INSTRUCTION OF TCCP PHYSICAL SCIENCE

Clarence D. Coleman
Norfolk State College
Norfolk, Virginia

and

H. Seymour Fowler
The Pennsylvania State University
University Park, Pennsylvania

Objectives: The purpose of this study was to compare the relative effectiveness of using or not using performance objectives prior to instruction on cognitive learning outcomes in the Thirteen College Curriculum Program Physical Science Course. More specifically, one group of students engaged in the assigned classroom activities without prior knowledge of performance objectives, and a second group of students was given lists of performance objectives prior to participating in the designated classroom activities.

Methods: Ninety-four freshmen non-science majors made up the sample, randomly divided into two sub-groups. The treatment consisted of providing performance objectives prior to the laboratory and lecture session to the experimental group. The control group was given a comparable "placebo" prior to instruction.

The Welch Science Process Inventory was used as a pre-test. After a twelve week exposure to the treatments the following criterion instruments were administered: (1) the Welch Science Process Inventory, (2) the Watson-Glaser Critical Thinking Appraisal, and (3) a teacher constructed achievement test.

The two groups were compared using an analysis of covariance on various learning-related parameters. The dependent variables were: achievement test scores, the Welch Science Process Inventory and the Watson-Glaser Critical Thinking Appraisal. The School and College Ability Test (SCAT) scores and the Welch Science Process Inventory (pre-test) scores served as covariates.

Results: The major hypothesis addressed itself to the achievement aspects of physical science and critical thinking. The data analyses revealed no statistically significant difference at the .05 level of significance in student achievement in physical science with or without prior knowledge of behavioral objectives.

The three sub-problems dealt with: (1) difference in achievement in physical science between control and experimental females, (2) differences in achievement in physical science between control and experimental groups in terms of academic areas of matriculation (business or education), and (3) difference in attitude toward science between males and females in the control and experimental groups. As in the case of the major hypothesis, an analysis of covariance of the data indicated that there was no statistically significant difference in group means.

The experimental results were indicative of the following conclusions:

1. The use of performance objectives prior to instruction appears to be equivalent to the standard laboratory procedure of not providing prior performance objectives.

2. Regardless of sex, there is no significant difference in academic achievement in science content whether or not performance objectives are utilized prior to laboratory instruction.

3. Regardless of major, there is no significant difference in academic achievement in science content whether or not performance objectives are provided prior to laboratory instruction.

4. The presence or absence of performance objectives prior to laboratory instruction doesn't appear to produce a significant difference in terms of attitudes toward science as it is related to the sex of students, when initial attitudes are controlled by an analysis of covariance.

Significance: This study failed to lend support to those individuals who advocate that the use of performance objectives will enable students to perform specified tasks better than those students who do not receive performance objectives. However, this investigator feels that the use of performance objectives should be employed in some form. In the survey question which was given during the examination period, ninety-seven percent of the forty-seven students who had been given the performance objectives (experimental group) indicated that these objectives were helpful, while only three out of the forty-seven students who were in the control group said that the objectives were helpful.

The time the student spends in understanding the material may have been reduced by the availability of performance objectives. If only five minutes were saved, the effort is worthwhile in terms of having more time to devote to other areas which may be confusing to the student.

IDENTIFICATION OF PERFORMANCE-BASED OBJECTIVES FOR CLASSROOM TEACHING STRATEGIES

Robert L. Uffelman
University of Delaware
Newark, Delaware

Objectives: The Delaware Model: A Systems Approach to Science Education (Del Mod System) is funded to meet the needs of Delaware teachers of science. Teachers indicated they needed to improve their teaching strategies. The objective of this inquiry was to determine their acceptance of performance-based objectives for selected teaching strategies.

Methods: A search of the literature revealed instructional tasks for seven areas of teaching strategies. Performance objectives were constructed for these. Then the objectives were tested for ambiguity with supervisors, science teachers and college faculty members. A survey instrument was constructed so subjects could indicate on a standard Scan form whether or not each of the thirty-three objectives was a realistic expectation of classroom teachers.

Data Sources: The sample (N = 47) included three randomly selected classes of teacher education majors attending the 1972 Summer Session. Subjects were stratified according to their years of experience and grade level teaching assignment.

Results: Results reveal that:

A. Grade level of the subjects did not influence acceptance of the objectives.

B. Inservice teachers, regardless of experience, accepted thirty-two of the thirty-three objectives as realistic.

C. More than two-thirds of each group rejected the objective that teachers should be able to "withhold verbal comment."

D. Seven objectives were judged "not realistic" by pre-service subjects as shown in the table on the next page.

Significance: It was concluded that classroom teaching experience is a factor influencing the acceptance of these objectives. This study indicates that preservice trainees should be provided experiences that enable them to gain proficiency in these strategies if they are to become competent classroom teachers.

Many groups advocate implementation of performance-based teacher education programs. Before such programs receive universal support, greater attention must be given to their acceptance by potential participants and by practicing professional educators. This study is a pilot investigation that led to further study of factors influencing their acceptance.

OBJECTIVES JUDGED AS UNREALISTIC EXPECTATION FOR

BEGINNING TEACHERS BY PRE-SERVICE TRAINEES

OBJECTIVE	PERCENT JUDGING UNREALISTIC
1. Diagnose the strengths and weaknesses of learners from a set of papers or tests and plan specific remediation tasks.	50.0
2. Vary the stimulus situation by pausing and pacing.	60.7
3. Plan discriminating questions (recall, higher order, evaluative, convergent, divergent).	64.3
4. Utilize a specific teaching behavior or skill in a classroom with varying types of students (slow learners, willing learners, heterogeneous groups).	67.9
5. Identify one teaching skill or behavior he wishes to modify from a taped lesson or micro-teaching session.	67.9
6. Evaluate the attending behavior of learners by observing posture, gaze level, and responses.	67.9
7. Construct a plan for securing questions, opinions, and responses for a group of learners or for individuals.	75.0

CONCURRENT SESSION X

Session Xa - An Hour With The President, Statler 1

J. David Lockard
University of Maryland
College Park, Maryland

Session Xb - An Hour With The Journal and Editorial Board, Hilton 1

O. Roger Anderson
Teachers College, Columbia University
New York, New York

Session Xc - Classroom Vignettes Workshop, Hilton 3

Gary C. Bates
Harvard Graduate School of Education
Cambridge, Massachusetts

GENERAL SESSION III

Chairman: Wayne W. Welch, National Science Foundation, Washington, D.C.
(On leave from University of Minnesota)

Speaker: Ralph Tyler, Science Research Associates, Chicago, Illinois.

"Research in Science Teaching in a Larger Context"

CONCURRENT SESSIONS XI

Session XIa - Symposium, Hilton 1

"Information Theory"

Chairman: Gene Moser

Participants: Moser, Gene, University of Pittsburgh, Pittsburgh, Pennsylvania

Fayio, Frank, University of Pittsburgh

Dunlop, David, University of Pittsburgh

Korth, Willard, University of Pittsburgh

Felen, Barbara, University of Pittsburgh

Session XIb - Joint AETS-NARST Panel, Hilton 3

"Secondary Science Teacher Education: Where Are We Going?"

Co-Chairmen: Burton Voss and John Schaff

Participants: Bell, Paul E., Pennsylvania State University
Westmeyer, Paul, Florida State University
Blosser, Patricia, The Ohio State University
Gallagher, James Joseph, Governors State University
Gale, Calvin, Michigan Technological University
Koran, John J. Jr., University of Florida
Morris, Victor, University of Maryland-Baltimore
Yager, Robert, University of Iowa
Townsend, Ronald, Evanston Township High School
Anderson, Harold, University of Colorado
Bridgham, Robert, Stanford University
Trowbridge, L. W., University of Northern Colorado
Voss, Burton, University of Michigan
Schaff, John, University of Toledo

THE USE OF INFORMATION THEORY TO STUDY HUMAN LEARNING

Gene Moser
Frank Fazio
David Dunlop
Willard Korth
Barbara Pelen
University of Pittsburgh, School of Education
Pittsburgh, Pennsylvania

Objectives: The belief that human behavior is normally Markovian has gained increasing acceptance among scientists in the past decade. That discovery has enabled the use of Information Theory to quantify the quality of learning behavior. However, the theory has yet to be adequately introduced to science researchers so they may use it as an interpretation tool.

A group of science educators at the University of Pittsburgh has applied information theorems to data of verbal and non-verbal behavior of children and adults. Several new information theoretic measures were derived and a model was developed to describe the flow of information as humans process such cognitive tasks as recall, delayed recall, and problem solving. In the past year, the research group has proven that information flow occurs in learning situations. Three major studies of recall and problem solving were conducted, and in each one it was found that the cognitive processes could be quantitatively described. It was discovered, in two of the studies, that the flow of information was characterized by levels of mental maturation.

Presentations: The symposium would be a presentation of the nature of Information Theory, its use in science education research, and of findings in learning studies. The findings would be used to illustrate the definitions of 27 information measures. The components of the symposium are as follows:

(1) The Information Theoretic Memory Model. The model and information measures will be defined and applied to human learning behavior. The trend lines for successful learning will be described through an explanation of the strength of dependence between cognitive actions.

(2) Design and Testing Problems in Measuring Information Flow. Information measures produce sigma values which preclude the use of most kinds of statistical tests. Several studies have been conducted to test the Markovicity of data and how the "real world data" are related to information measure values. The problems and solutions will be illustrated with research data from behavior studies.

(3) Problem Solving Behaviors and Perceptive Modalities. There is a long history of failure to define problem solving and behaviors of problem solvers. This study describes how children, aged six to eighteen years, solve a problem through verbal and non-verbal behavior. Information flow through these two task approaches will be compared and illustrated.

(4) Structuredness and Learning Behaviors. There is some evidence that structuredness increases as learning occurs. A special study was conducted to test this hypothesis. The data of behavior from a learning situation was enumerated and then a computer simulation of those behaviors was conducted. The information measure values for both cases will be compared for degrees of structuredness, from that of the real world behaviors to that of randomly generated simulations, and for changes in structuredness occurring in humans as they learned how to solve problems.

(5) The Flow of Information in Classification Sorting Tasks Processed By Concrete and Formal Operational Level Children. The study was conducted to determine differences in the information flow of sorting and recall actions made by children of operation levels. Furthermore, the change of information flow was measured when classification sorting was contextualized. The differences in information flow will be interpreted in Piagetian terminology.

NARST-AETS JOINT PANEL

SECONDARY SCIENCE TEACHER EDUCATION: WHERE ARE WE GOING?

John Schaff, University of Toledo and Burton Voss, University of Michigan
Co-Chairmen

Panel participants have been asked to prepare a paper responding to the discussion topic: Secondary Science Teacher Education: Where Are We Going? Papers are to discuss this topic in relation to recent trends and developments in the panelists' institutions. Panelists are asked to include results of their own research and development activities and to suggest implications for the future.

Panelists will have exchanged papers in advance of the presentation at Detroit. The discussion will be open to all registered NARST members. Audience participation will be encouraged.

The panelists and the institutions they represent are as follows:

Paul E. Bell	Pennsylvania State University
Paul Westmeyer	Florida State University
Patricia Blosser	Ohio State University
James Joseph Gallagher	Governors State University
Calvin Gale	Michigan Technological University
John J. Koran, Jr.	University of Florida
Victor Morris	University of Maryland-Baltimore
Robert Yager	University of Iowa
Ronald Townsend	Evanston Township High School
Harold Anderson	University of Colorado
Robert Bridgham	Stanford University
L. W. Trowbridge	University of Northern Colorado
Burton Voss	University of Michigan
John Schaff	University of Toledo